CHAPTER IV
SEGREGATION AND IDENTIFICATION

A. SEGREGATION AT THE SOURCE

1. The most critical rule in the initial handling of scrap is to ensure source segregation at all locations where scrap is initially generated. Chapter V specifies the Scrap Classification List (SCL) codes and industry standards to be used as guides in identifying each type of scrap as it is segregated. Chapter VI provides further guidance relative to identification of precious metal-bearing scrap. Source segregation is particularly applicable to production shops, machine shops and repair shops where several different scrap materials are being generated—since it is very difficult, and often not feasible, to segregate scrap after arrival at a scrap yard. As indicated in chapter II, top priority attention should be given to nonferrous scrap (including precious metal-bearing scrap) and to other metallic scrap containing high-value alloys.

2. Generations of metal clippings and trimmings, shearings, and skeleton stampings should first be considered for possible reuse. For example, scrap skeletons produced during punching or stamping operations can sometimes be used to produce smaller stampings. When baling skeletons, the longer pieces are useful as wrappers to form the outside of the bundle.

3. If scrap containing different metal alloys is kept separate and free from contamination, it can be economically melted into ingots of the same composition as the original material from which it was generated. But if scrap containing different metal alloys become commingled or contaminated, it is likely to end up in a smelter where its valuable alloy content may be lost. If there is too much contamination, it may not be feasible to recycle the high value metals contained in such scrap.

4. One of the best methods of segregation at the source is to place properly marked containers where each type of scrap can be collected without further handling as it is generated. If this is not practicable, containers should be located in such a way as to facilitate direct transfer of segregated floor sweepings. Whenever there is a change in the material being worked, the machine should be thoroughly cleaned and properly marked new containers should replace the old ones. As containers are filled and delivered to the scrap yard, they will be emptied into large hoppers or into bins containing similar materials. It is essential that all containers, hoppers and bins be kept free from contamination and that the identity of each type of scrap generated is maintained throughout the entire scrap disposal process.

5. A good method of marking containers, hoppers and bins is to paint a band of distinctive color around them to identify the specific type of scrap to be placed therein—without any commingling or contamination with other property. More specific identification of the kind of scrap contained therein can be accomplished by fastening a color-coded tag marked with the appropriate alloy type, specification or code number; and machines generating this scrap should be marked with identical tags.

6. Full cooperation in source segregation must be obtained from everyone concerned with scrap handling. Otherwise, scrap containers are likely to be used as a place to dump the remains of lunch boxes, bottle caps, empty cigarette packages, and other contaminants. To minimize such contamination, supervisors should conduct a continuing educational campaign to stress the critical importance of scrap segregation; and they should ensure that separate refuse containers are provided in a nearby location to minimize" the temptation to misuse scrap containers.

B. IDENTIFICATION OF METALLIC SCRAP

1. *Visual Identification.* This method is used to identify metallic scrap in terms of color, use, and weight. Most metallic scrap turned in to DoD scrap yards can be classified into four color categories red, pink, yellow and silver gray. It can be further classified by weight in terms of heavyweight, lightweight, or mediumweight. If information is readily available as to the use made of the items from which the scrap was derived, further identification tests may not be necessary.

2. *Magnetic Testing.* Magnetic testing makes use of magnets to determine whether or not the scrap contains ferromagnetic materials (i.e., iron, nickel and cobalt) or nonmagnetic materials. Iron-base alloys (i.e., cast iron, plain carbon and low-alloy steels) are most likely to be magnetic, although a few nickel alloys are also magnetic. A small permanent magnet can be used for this purpose. However, it is important to note that magnetic testing can serve only as an initial approxi-

mate classification of alloys. It should never be used as a conclusive test (except to separate two alloys of known composition, one being magnetic and the *other* nonmagnetic).

3. *Spark Testing,*

a. Spark testing makes use of the fact that some metals, in a finely divided state, will oxidize rapidly when heated to a high enough temperature. When such metals are ground by a high-speed grinding wheel, the fine particles torn loose are oxidized and raised to an incandescent temperature through the heat of friction on the wheel.

b. Among the commercially important alloys, those with an iron, nickel, monel or titanium base give characteristic sparks. Certain elements used as alloying agents in steel impart characteristic and recognizable variations in the sparka produced by basic carbon steel (see Table IV-l).

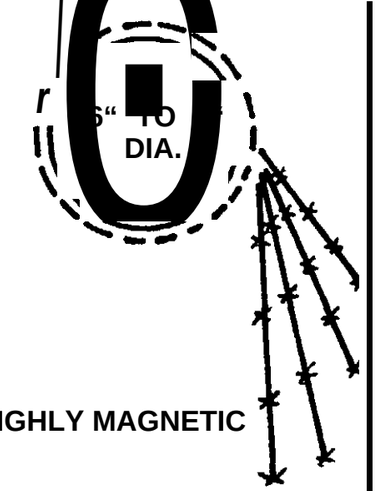
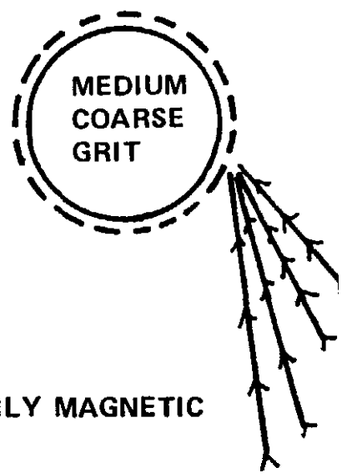
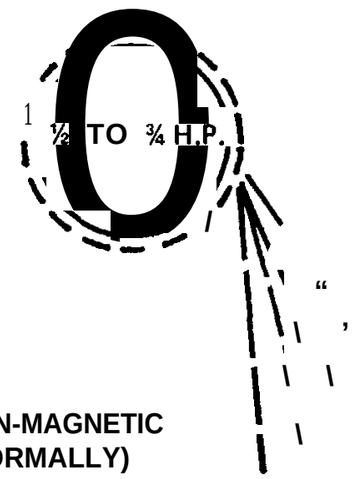
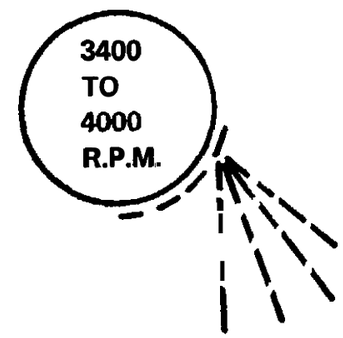
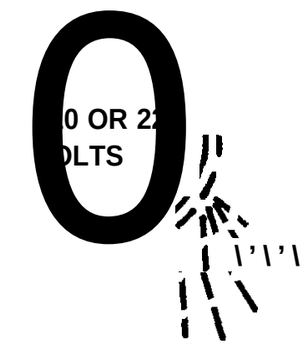
c. Proficiency in spark testing requires practice and reproducibility in sparking results. Lighting conditions should be approximately the same each time when sparks are being examined against a dark background. Care should be taken to apply the same amount of pressure over the same sparking area in each test. Only with such reproducibility, or by comparison with sparks produced from samples with known compositions, can spark testing be depended on for identification.

d. Spark tests are conducted on a high-speed portable or bench power grinder. When a portable grinder is used, the wheel of the grinder is usually touched to the sample so that sparks fly off horizontally. Use of safety glasses is mandatory to ensure eye protection. When a bench grinder is used, checks should be made to ensure that the grinder tongue guard and tool rest are adjusted properly. The preferred method is to hold the test sample and touch it to the grinding wheel (see Figure IV-l). The surface speed should be at least 8,000 rpm. However, a stationary grinder or bench grinder turning a medium-coarse abrasive wheel at 3,400 to 3,600 rpm is satisfactory if care is taken to exert the same relative pressure against each sample. Grinding wheel composition is most important and must be appropriate to the type of metal being spark tested. For normal carbon steel alloys used in construction, Carborundum (usually described as aloxite resinold, A36–Q–B4–3 x ⅜ x ⅜) should be used. However, in spark testing of tool steel or stainless steel it may be best to make use of other types of grinding wheels and the alloy producer should be consulted for the most appropriate wheel designation.

e. To prevent possible contamination of the spark from particles retained in the wheel during previous spark tests, grinding wheels should be cleaned frequently.

TABLE IV-I

SPARK TESTING CHART
(COPPER FREE METALS)

NORMAL CARBON STEEL	400 SERIES CHROME STAINLESS STEEL	300 SERIES STAINLESS STEEL, 18-8 ALLOY	310 SERIES STAINLESS STEEL, 25-20 ALLOY	NICKEL AND COBALT HIGH TEMPERATURE ALLOYS
				
HIGHLY MAGNETIC	HIGHLY MAGNETIC	NON-MAGNETIC (NORMALLY)	NON-MAGNETIC	NON-MAGNETIC
HEAVY DENSE SPARKS 18” TO 24” LONG WHICH TRAVEL COMPLETELY AROUND THE GRINDING WHEEL.	SPARKS ARE NOT AS HEAVY OR AS DENSE AS THOSE OF NORMAL CARBON STEEL.	SPARKS ARE NOT AS HEAVY OR AS DENSE AS THOSE OF NORMAL CARBON STEEL.	THE SPARK STREAM IS THIN AND FROM 4“ TO 8“ LONG.	THE SPARK STREAM IS THIN AND ABOUT 2“ LONG.
SPARKS ARE WHITE TO STRAW COLORED WITH STAR BURSTS AND SHELL BURSTS THROUGHOUT.	SPARKS ARE 14” TO 18” LONG, TRAVEL COMPLETELY AROUND THE GRINDING WHEEL AND ARE ORANGE TO STRAW COLORED ENDING WITH THE APPEARANCE OF A SPLIT TONGUE.	SPARKS ARE 12” TO 18” LONG, TRAVEL COMPLETELY AROUND THE GRINDING WHEEL AND ARE ORANGE TO STRAW COLORED ENDING IN A STRAIGHT LINE WITH FEW, IF ANY, STAR BURSTS OR SHELL BURSTS.	SPARKS ARE ORANGE TO RED IN COLOR, DO NOT TRAVEL AROUND THE GRINDING WHEEL WITH NO STAR BURSTS OR SHELL BURSTS.	SPARKS ARE DARK RED IN COLOR, DO NOT TRAVEL AROUND THE GRINDING WHEEL WITH NO STAR BURSTS OR SHELL BURSTS.

NOTE: THE SHORTER AND REDDER THE SPARK THE MORE NICKEL AND/OR COBALT IN THE ALLOY.
THE LESS WHEEL HUGGING OF SPARKS THE MORE NICKEL AND/OR COBALT IN THE ALLOY.

Figure IV-1. Spark testing metal on a grinding wheel.

4. *Chemical Spot Testing*

a. Chemical spot testa used for sorting or final identification of materials show attack or lack of attack by specific chemicals to determine the presence or absence of specific alloying elements. Spot tests are based on the formation of characteristic colors or precipitates of the unknown elements when those elements react with various test chemicals. Such tests may also be carried out electrographically on falter paper or on spot plates (see figure IV-2).

b. Electrographic spot tests make use of a metal "sandwich" consisting of a piece of aluminum or platinum on the outside and two pieces of filter paper moistened with an appropriate solution on each side of the sample in the middle of the sandwich. Current from two dry-cell batteries is then passed through the filter paper for a specified length of time—with the unknown metal serving as the anode, and the inert metal on the outside of the sample serving as the cathode. The filter paper will thus be impregnated with dissolved matter from the sample. The filter paper is then removed from the sandwich and treated with suitable reagents to bring out the desired color reactions. Filter paper one-half to one inch square is large enough for this work.

c. A more common type of spot test involves placing one or two drops of an acid or alkali on the surface of the sample, transferring the drops to a reagent-impregnated filter paper, or transferring it to a spot plate.

d. Capillary tubea are usually best for placing drops on test samples, since minimum quantities of the reagent used will give the best results. However, it may sometimes be better to conduct spot testing in test tubes.

e. It is important to remember that, except under rigid laboratory control, spot tests are no more than qualitative testa. If more precise tests are needed, scrap yard personnel should seek professional assistance from the nearest available laboratory facility.

Figure IV-2. Chemical spat testing.

C. SIMPLIFIED METAL TESTING AND SORTING PROCEDURES

1. General. Scrap yard personnel can proceed step by step, as indicated below, to determine the probable composition of metallic scrap (see Figure IV-3).

2. *Visual Identification.*

a. Color Criteria:

(1) Red or reddish color indicates copper.

(2) Light brown or tan color indicates 90/10 cupro-nickel.

(3) Dark yellow color indicates bronze.

(4) Light yellow color indicates brass.

(5) Bluish or dark gray color indicates zinc, kirksite or lead.

(6) White or light gray color indicates aluminum or magnesium.

b. Weight Criteria

(1) Heavyweight samples include platinum, tungsten, gold, mercury, lead, silver, or molybdenum.

(2) Lightweight samples include magnesium, aluminum or titanium.

(3) Mediumweight samples include most other metals.

3. *Magnetic Testing.*

a. Strongly magnetic samples include steel, iron, nickel, cobalt, and 400 series chromium stainless steels.

b. Slightly magnetic samples include monel (except "K' monel) and occasionally 90/10 cupro-nickel, manganese bronze, aluminum bronze and silicon bronze. Also, ordinary stainless steels of the 300 series, which are normally nonmagnetic, may develop slight magnetic properties after having been subjected to extreme heat or pressure for prolonged periods.

c. Nonmagnetic samples include nearly all other metals, including "K" monel.

4. *Spark Testing.* Different metals and alloy combinations impart characteristic sparks which aid in the identification of the metals. Since the sparking characteristics of many different metals are so similar, other means must usually be employed to verify the identity of test samples. The principal criteria that should be considered when observing a spark test are:

a. Length of carrier lines.

b. Color of sparks.

c. Density of carbon star bursts (none, few, many).

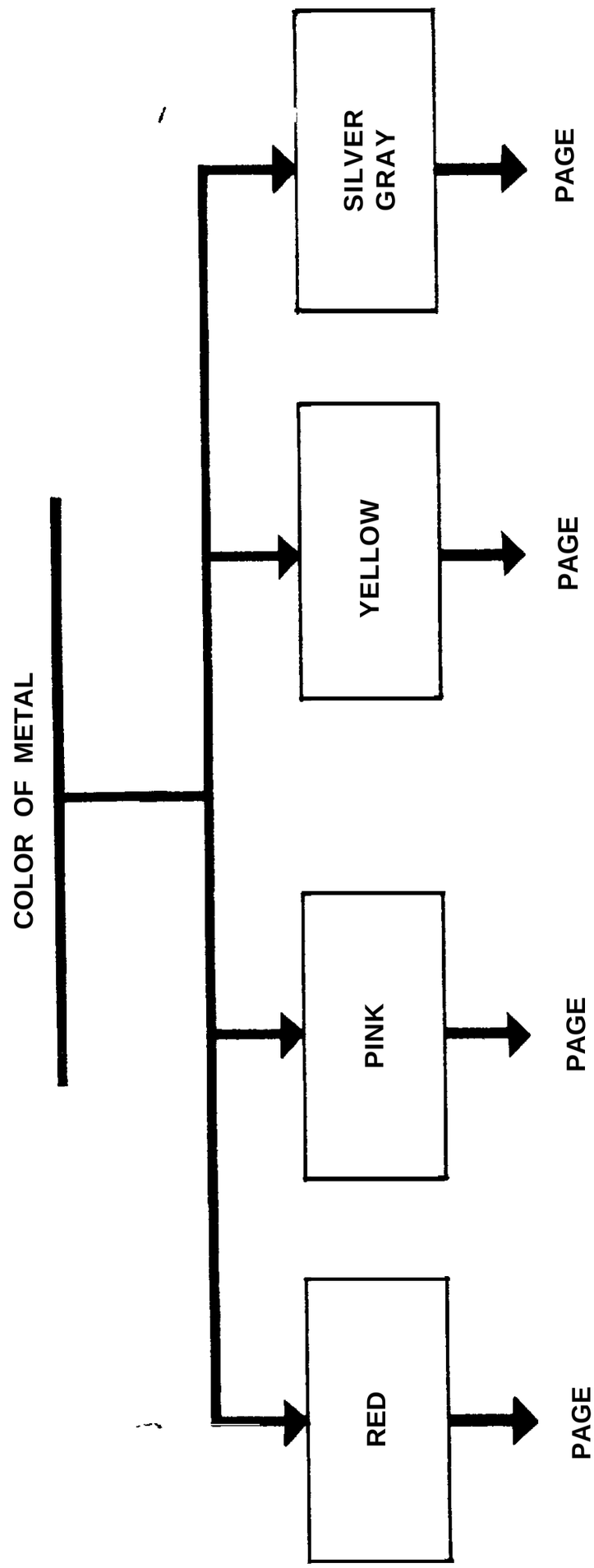
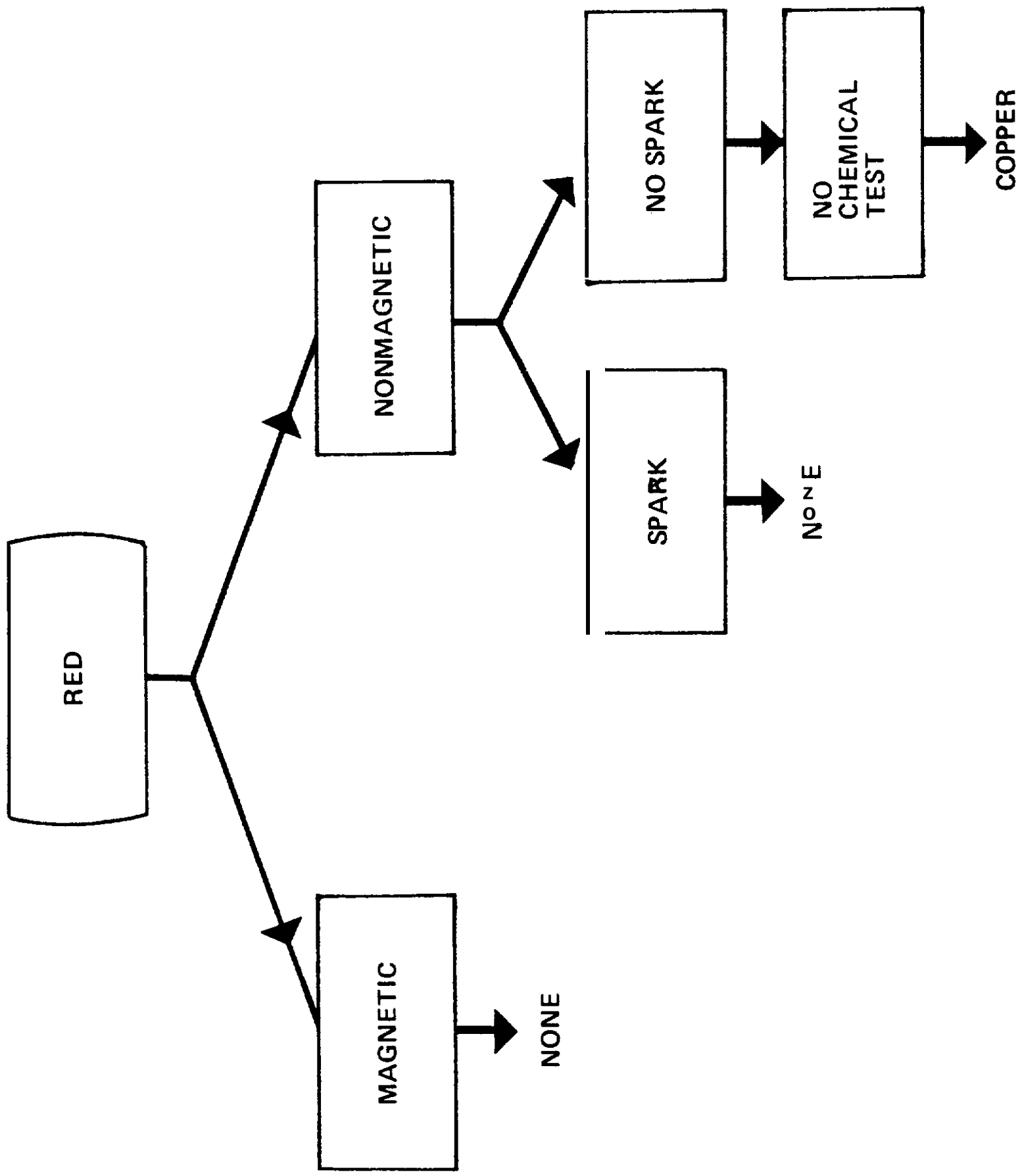
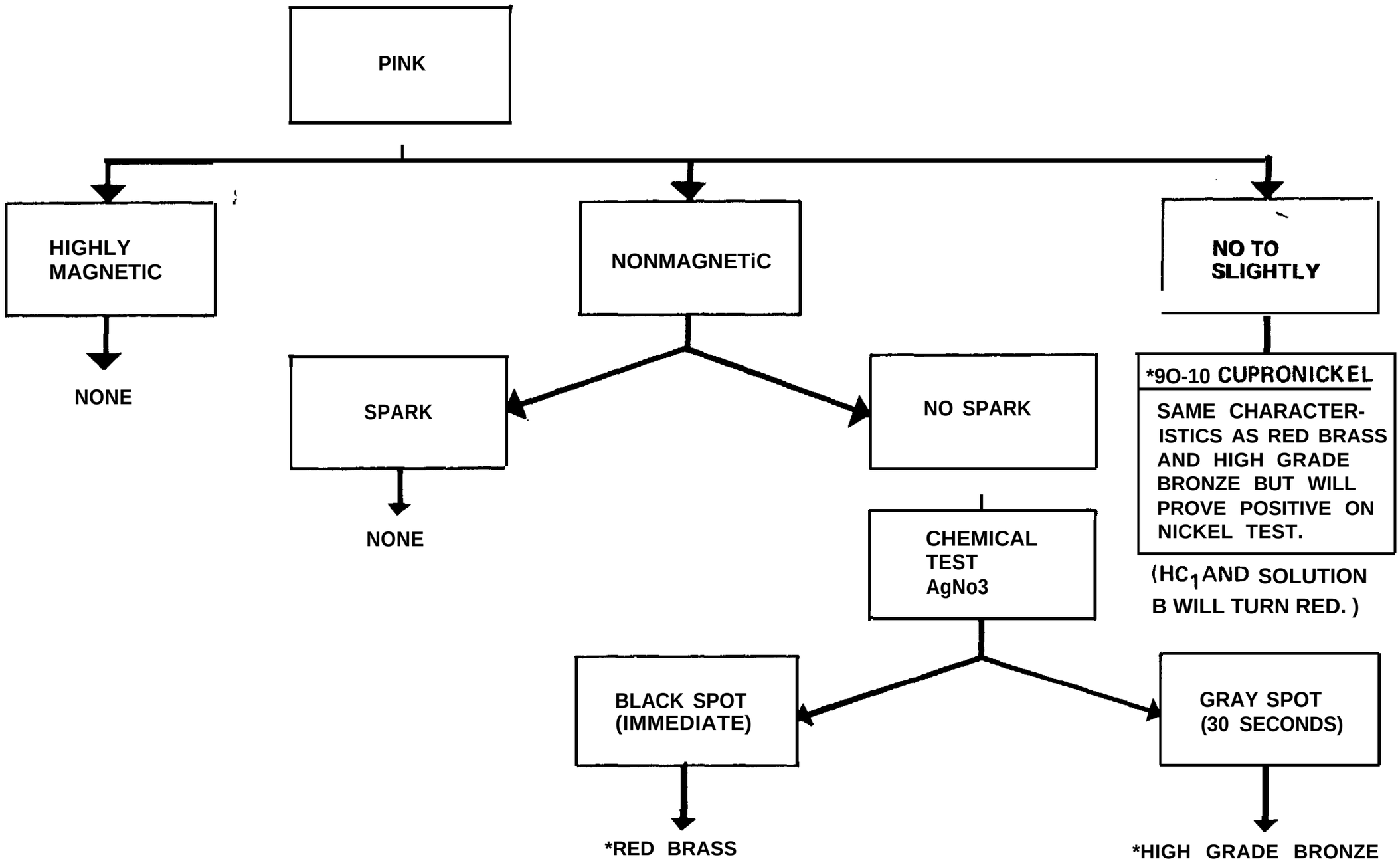
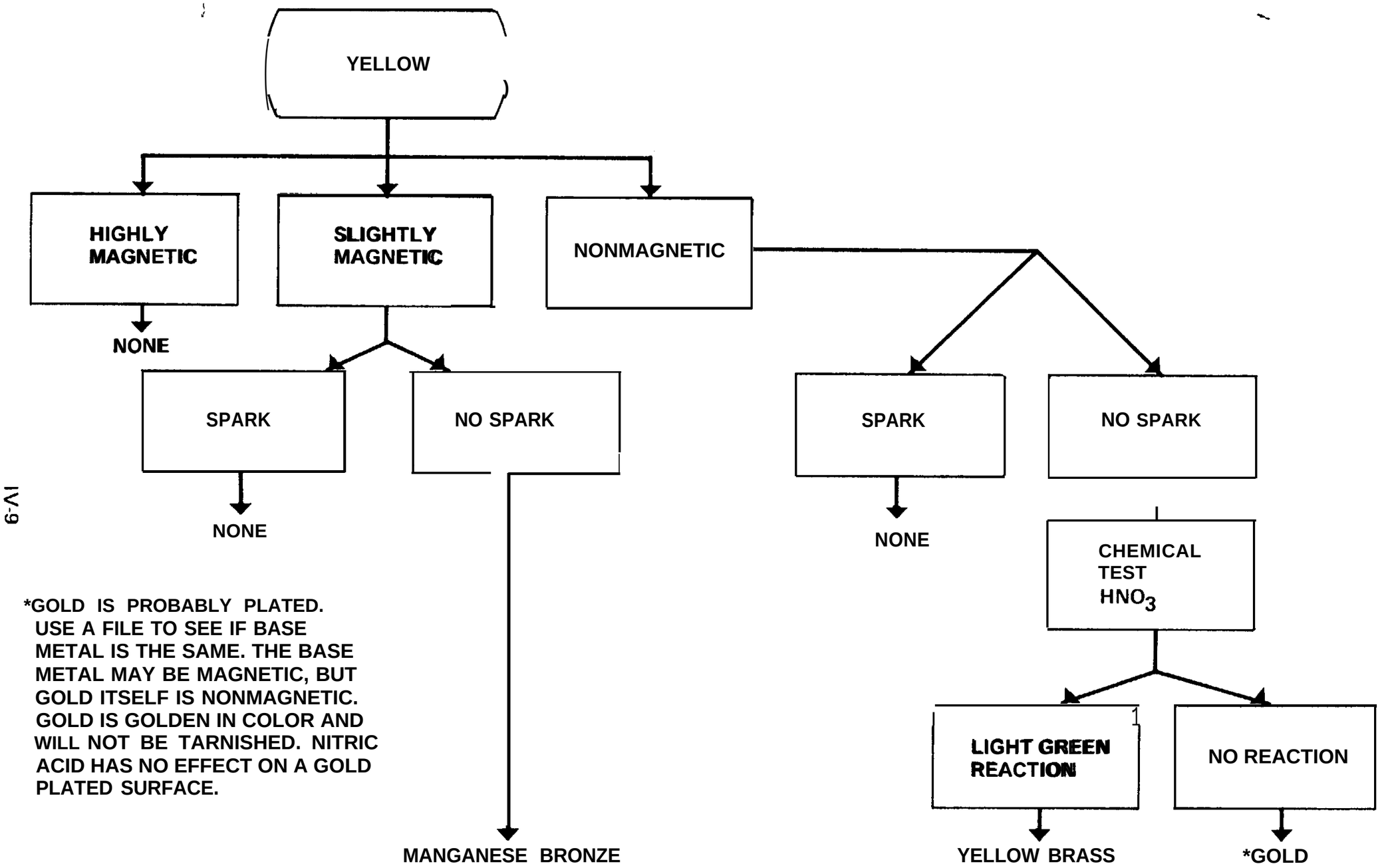

METALS IDENTIFICATION
COLOR OF METAL
SILVER GRAY
PAGE
YELLOW
PAGE
PINK
PAGE
RED
PAGE

FIGURE IV-3

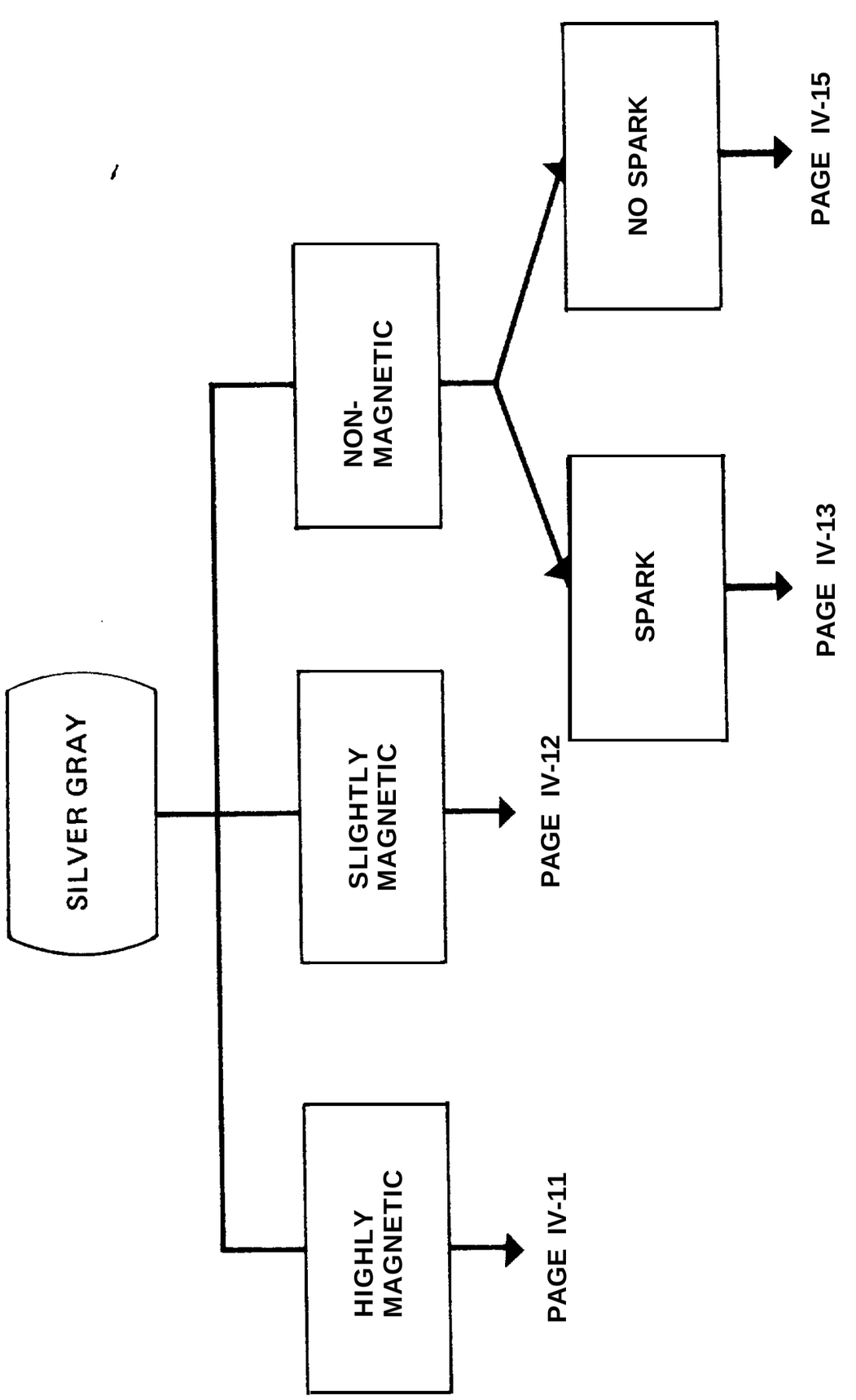

RED
NONMAGNETIC
NO SPARK
NO CHEMICAL TEST
COPPER
SPARK
NONE
MAGNETIC
NONE



(SEE NOTE UNDER 90-10 CUPRONICKEL)

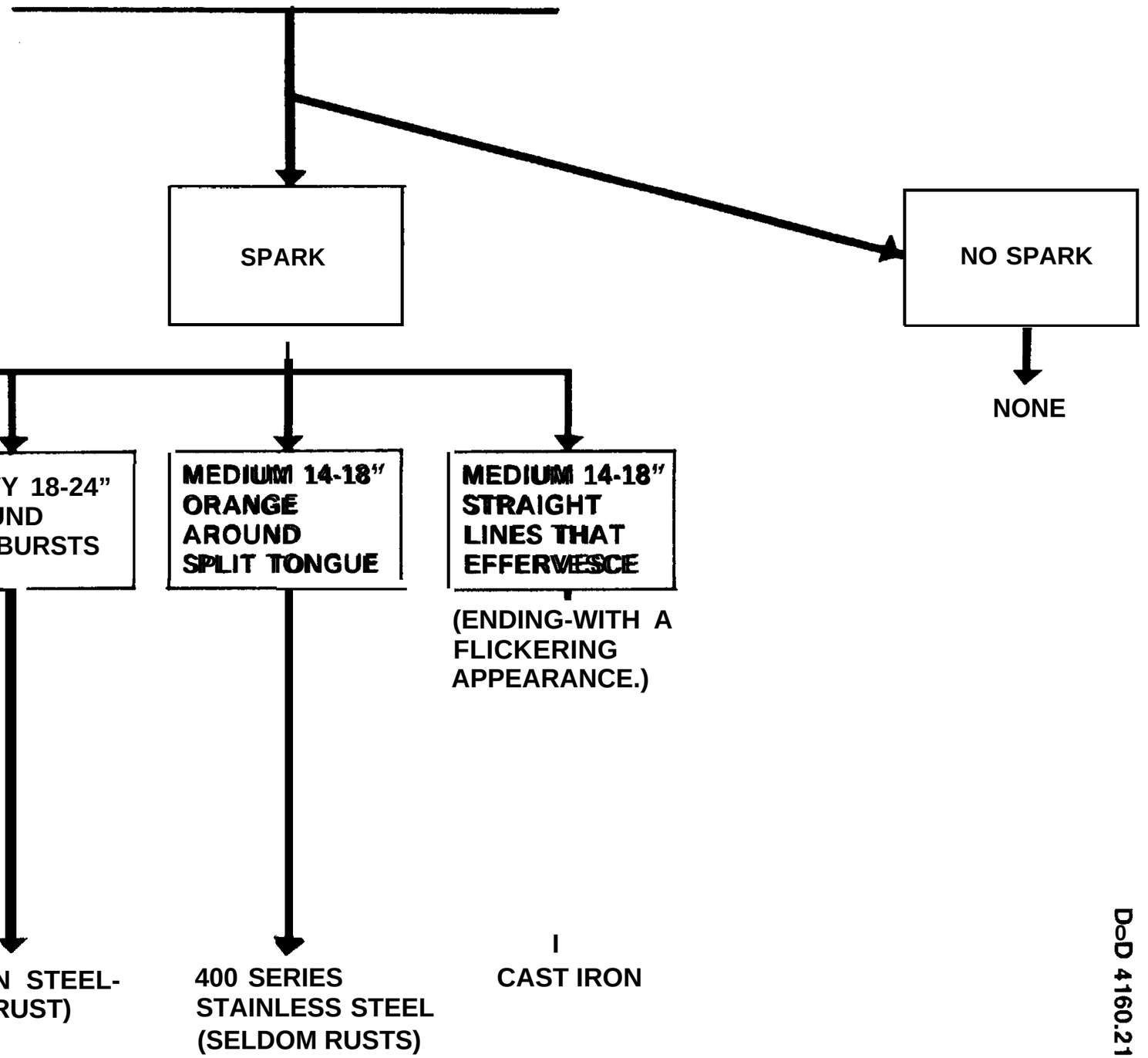


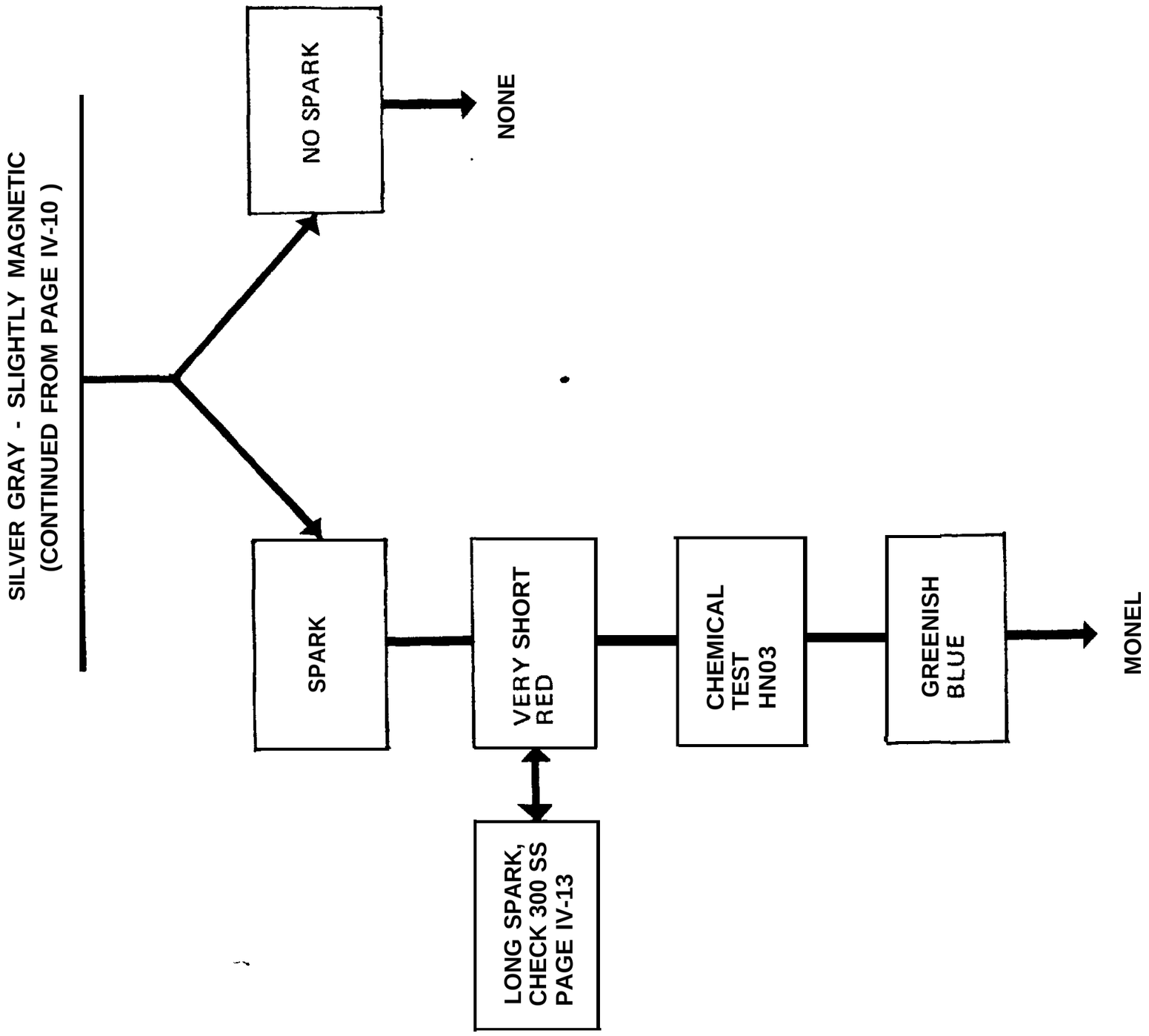
*GOLD IS PROBABLY PLATED. USE A FILE TO SEE IF BASE METAL IS THE SAME. THE BASE METAL MAY BE MAGNETIC, BUT GOLD ITSELF IS NONMAGNETIC. GOLD IS GOLDEN IN COLOR AND WILL NOT BE TARNISHED. NITRIC ACID HAS NO EFFECT ON A GOLD PLATED SURFACE.


SILVER GRAY
SLIGHTLY MAGNETIC
PAGE IV-12
NON-MAGNETIC
SPARK
PAGE IV-13
NO SPARK
PAGE IV-15
HIGHLY MAGNETIC
PAGE IV-11

SILVER GRAY - HIGHLY MAGNETIC

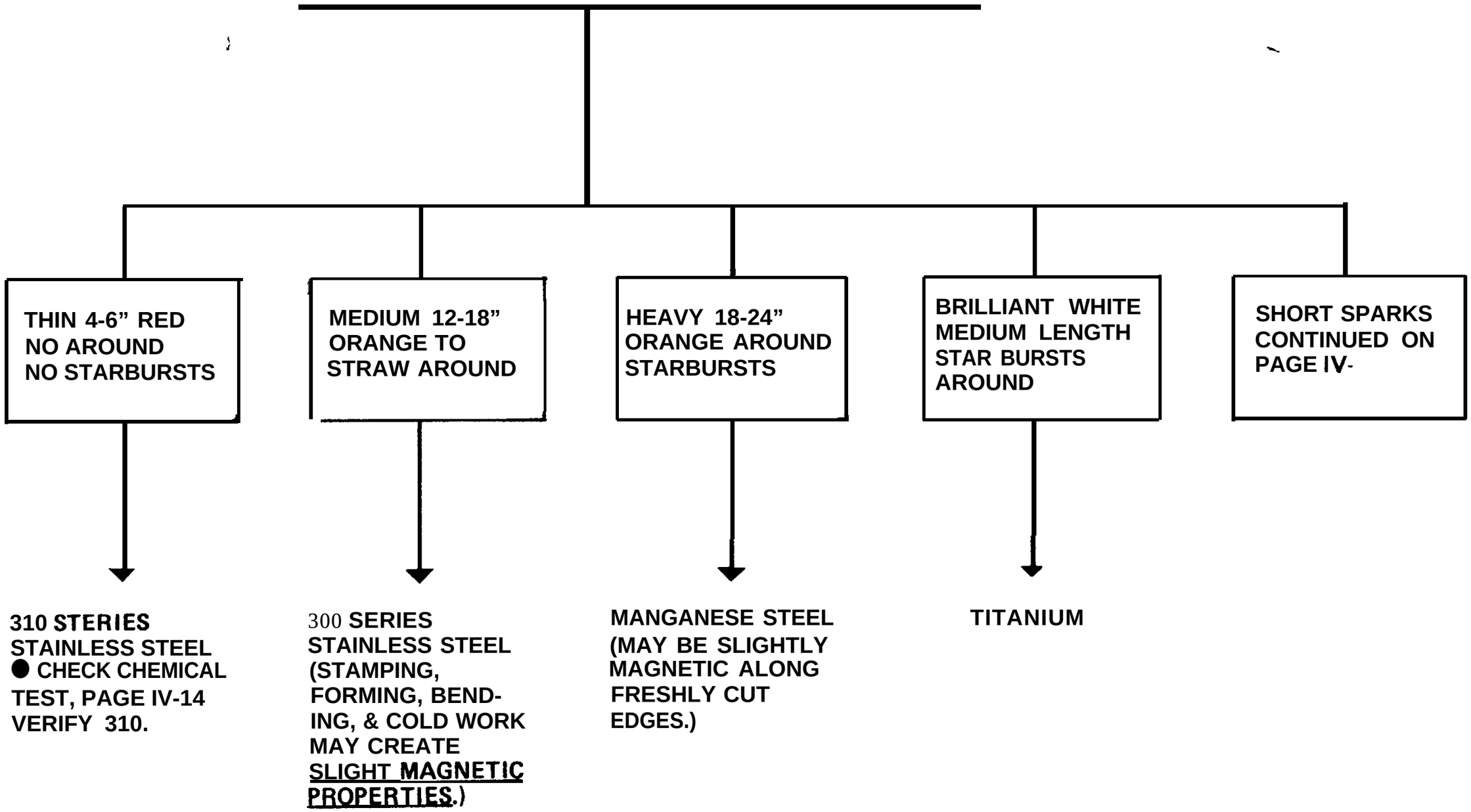
(CONTINUES FROM PAGE IV-10)

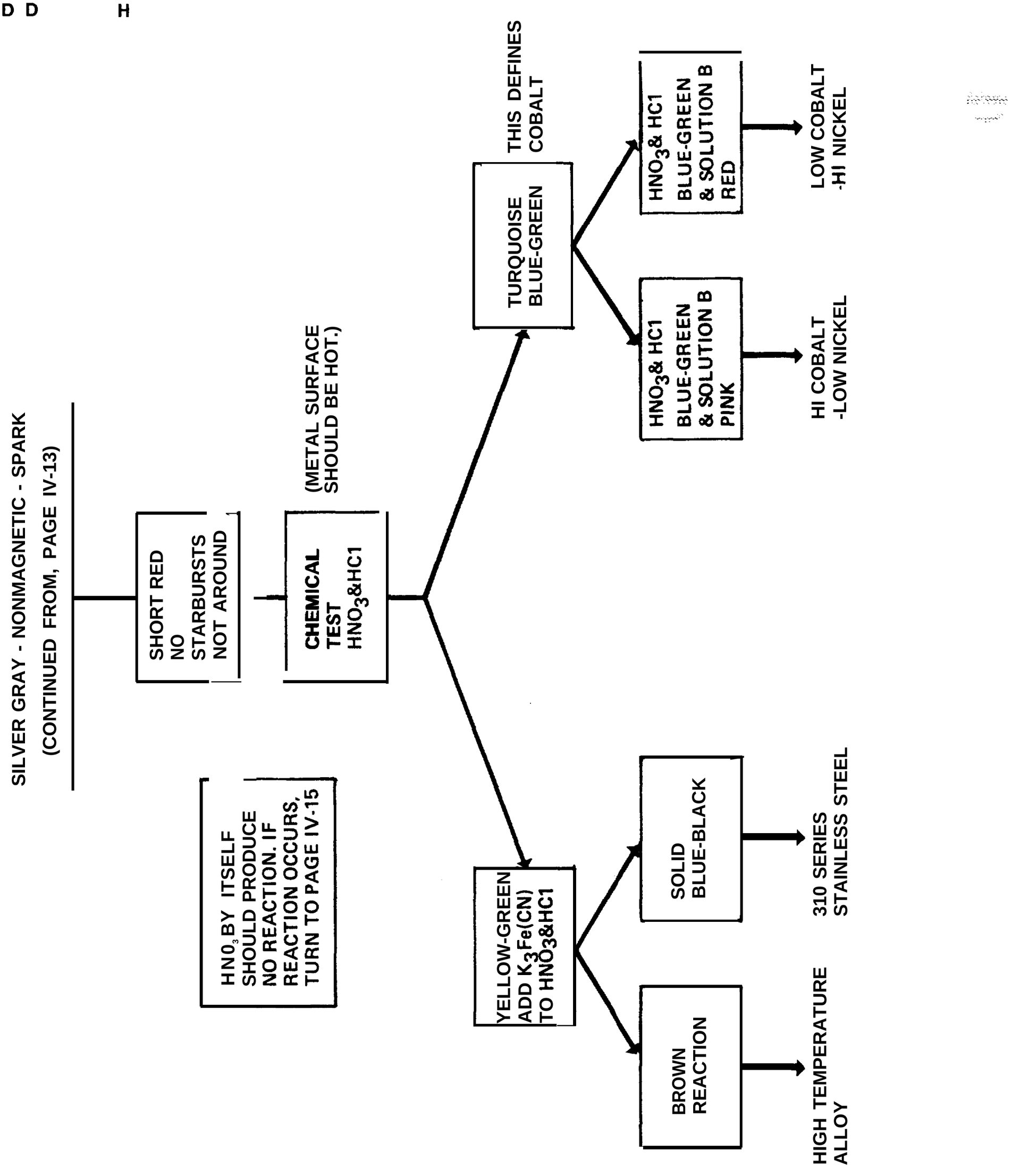



SILVER GRAY - SLIGHTLY MAGNETIC
(CONTINUED FROM PAGE IV-10)
NO SPARK
NONE
SPARK
VERY SHORT
RED
CHEMICAL
TEST
HN03
GREENISH
BLUE
MONEL
LONG SPARK,
CHECK 300 SS
PAGE IV-13

SILVER GRAY - NOMAGNETIC - SPARK

(CONTINUED FROM PAGE IV-12 - CONTINUED ON PAGE IV-14)



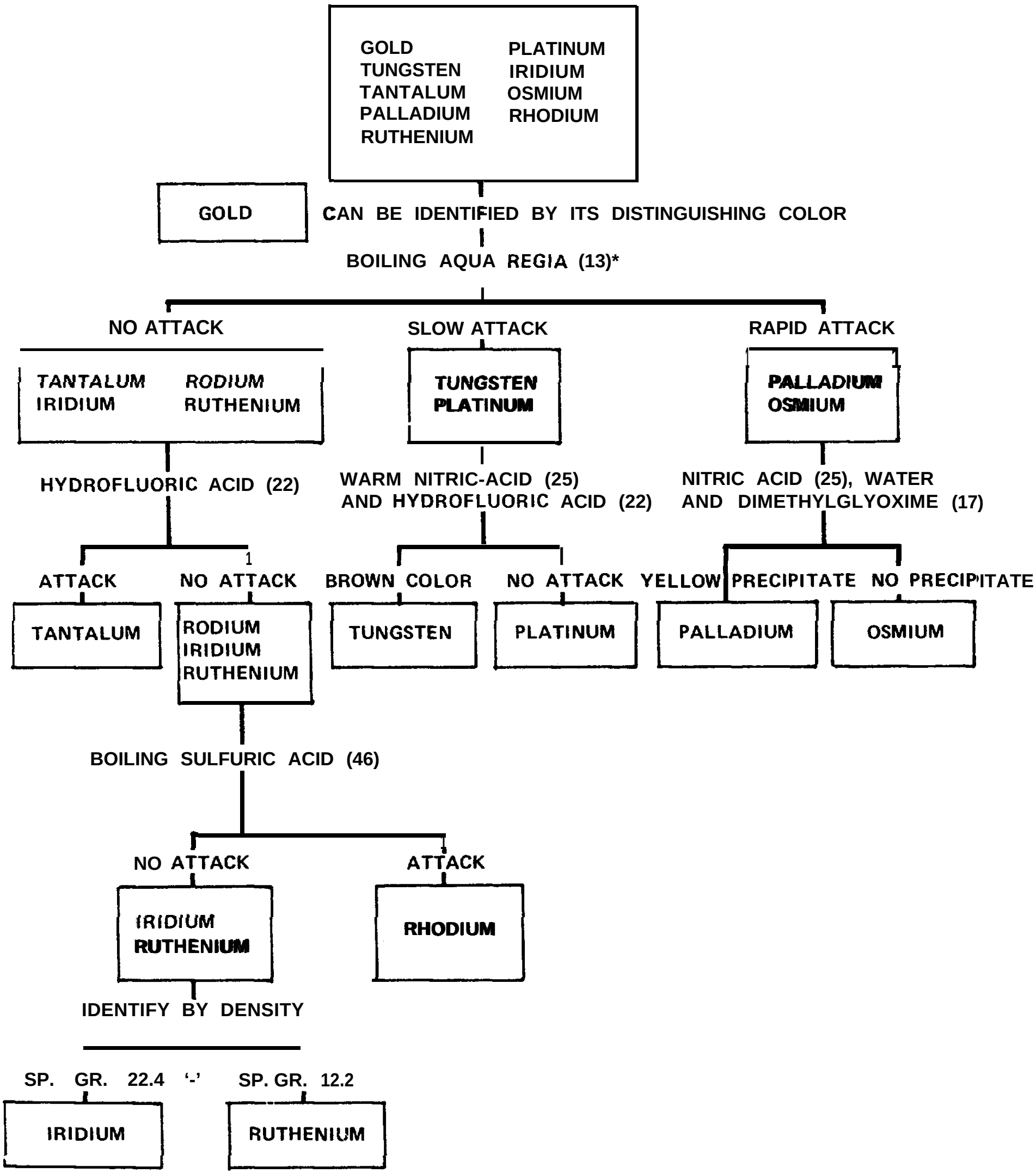

SILVER GRAY - NONMAGNETIC - SPARK
(CONTINUED FROM, PAGE IV-13)
SHORT RED
NO
STARBURSTS
NOT AROUND
CHEMICAL
TEST
HNO3&HC1
(METAL SURFACE
SHOULD BE HOT.)
TURQUOISE
BLUE-GREEN
THIS DEFINES
COBALT
HNO3& HC1
BLUE-GREEN
& SOLUTION B
PINK
HI COBALT
-LOW NICKEL
HNO3& HC1
BLUE-GREEN
& SOLUTION B
RED
LOW COBALT
-HI NICKEL
HN0 3 BY ITSELF
SHOULD PRODUCE
NO REACTION. IF
REACTION OCCURS,
TURN TO PAGE IV-15
YELLOW-GREEN
ADD K3Fe(CN)
TO HNO3&HC1
SOLID
BLUE-BLACK
310 SERIES
STAINLESS STEEL
BROWN
REACTION
HIGH TEMPERATURE
ALLOY

SILVER GRAY - NONMAGNETiC - NO SPARK

(CONTINUED FROM PAGE IV-14)

- LIGHT WEIGHT METALS
  - CHEMICAL TEST $AgNo_3$
    - BLACK SPOT ON METAL → MAGNESIUM
    - NO REACTION → ALUMINUM
- MEDIUM AND HEAVY WEIGHT METALS
  - CHEMICAL TEST HNO_3
    - VIGOROUS REACTION BROWN SMOKE WHITE PRECIPITATE → TIN
    - VIGOROUS YELLOW REACTION BROWN SMOKE → ZINC
    - BLUE-GREEN REACTION → NICKEL SILVER (WHEN METAL IS DIPPED IN WATER, SPOT WILL TURN PINK.)
    - BLUE-GREEN → 70-30 CUPRONICKEL → THIS METAL WILL PRODUCE A VERY SHORT SPARK IF HARD PRESSURE IS APPLIED.
    - HNO_3 & HC1 MILKY WHITE PRECIPITATE → SILVER (SILVER MAY BE PLATED. USE A FILE TO SEE IF BASE METAL IS THE SAME.)
    - SLIGHT YELLOW REACTION → CADMIUM
    - NO REACTION → LEAD

CHART 1
IDENTIFICATION OF VERY HEAVY METALS
(SPECIFIC GRAVITY 12 TO 22)



*THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-4

PROCEDURE FOR CHART 1

/ VERY HEAVY METALS, specific gravity 12 to 22—gold, tungsten, tantalum, palladium, platinum and platinum-group metals (osmium, iridium, rhodium end ruthenium). Consult chart 1.

A. GOLD can be identified by ita distinguishing color; the other metals are white or grayish white.

B. Immerse in boiling aqua regia (13)" and observe at the end of 2 minutes.

1. No attack indicates tantalum, iridium, rhodium or ruthenium. Add hydrofluoric acid (22).

a An attack indentifies *Tantalum*.

b. No attack indicates iridium, rhodium or ruthenium. Immerse in boiling' sulfuric acid (46) end observe at the end of 2 minutes.

(1) An attack identifies *Rhodium*,

(2) No attack indicates iridium or ruthenium.

Identify by density.

(a) *Ruthenium sp. gr. 12.2.*

(b) Iridium, sp. gr. 22.4

2. A slow attack indicates platinum or tungsten.

Immerse in nitric acid (25) and hydrofluoric acid (22), warm, end observe at the end of 2 minutes.

a An attack and brown color identifies Tungsten.

b. No attack identifies *Platinum.*

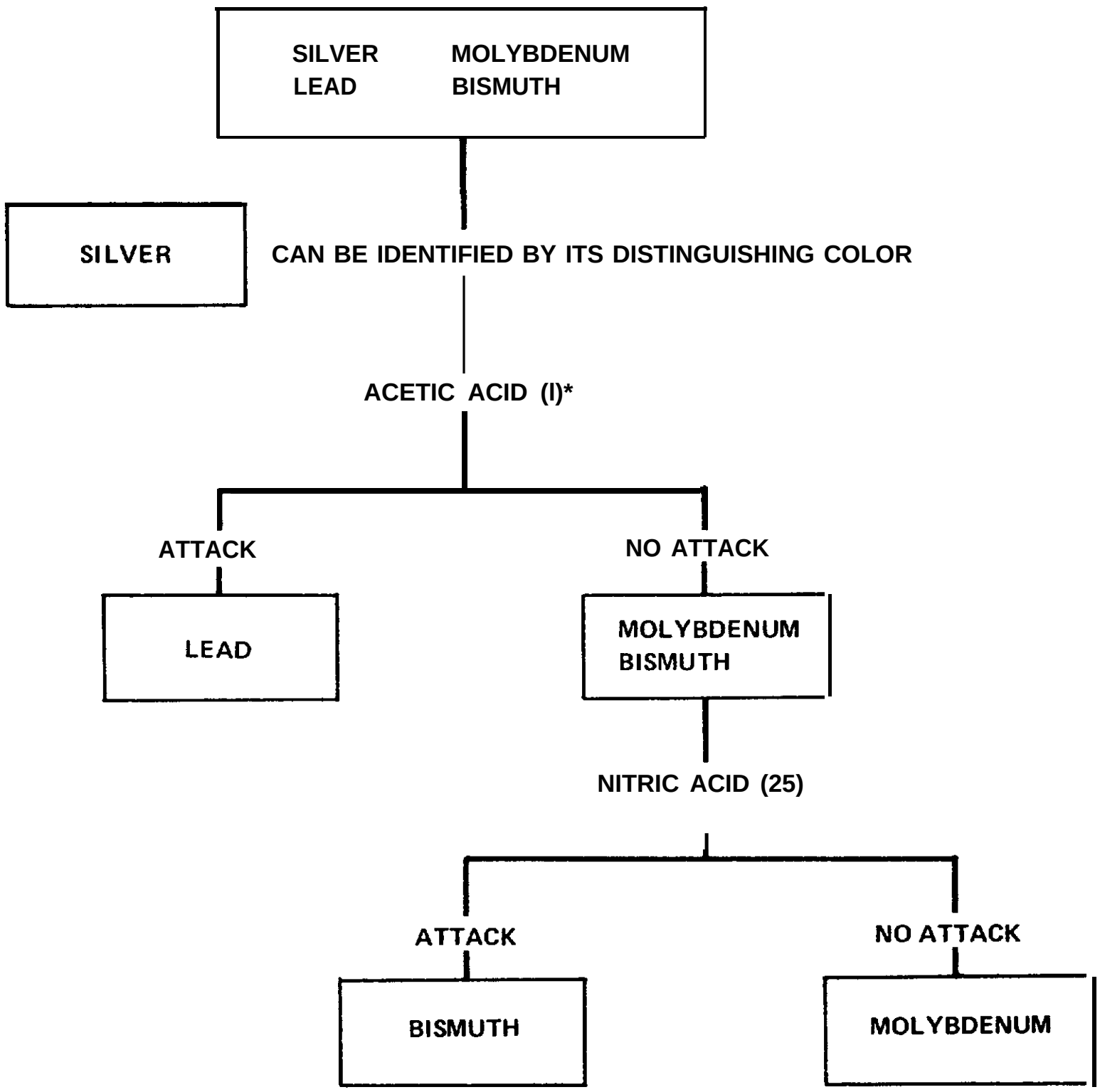
3. A rapid attack indicates osmium or palladium.
Immerse in hot nitric acid (25), dilute with water, and add dimethylglyoxime (17).

a A yellow precipitate identities *Palladium*.

b. Attack, but no precipitate identifies *Osmium.*

"The figure in parentheses refers to the reagent listed in table IV-2

CHART 2
IDENTIFICATION OF HEAVY METALS
(SPECIFIC GRAVITY 9.8 TO 11 .3)



*THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-5

PROCEDURE FOR CHART 2

/ HEAVY *METALS*, specific gravity *9.8* to 11.3—lead, silver, molybdenum and bismuth. Consult chart 2.

A. *Silver* can be identified by ita distinguishing color; the other metals are white or grayish-white.

B. Add acetic acid (1) and observe at the end of 1 minute.

1. An attack identifies *Lead*.

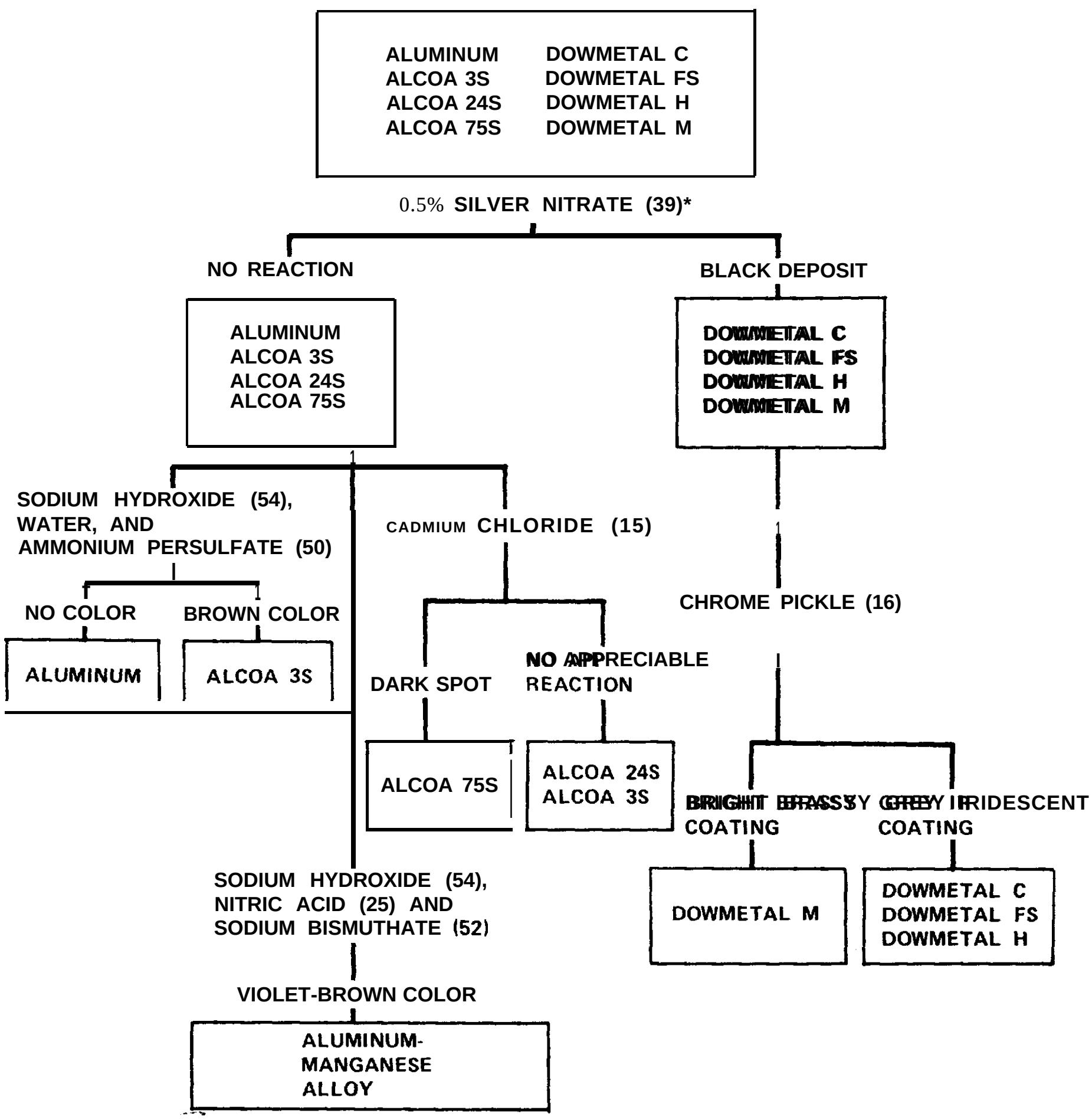
2. No attack indicates molybdenum or bismuth. Add nitric acid (25) and observe at the end of 1 minute.

a. An attack identifies *Bismuth*.

b. No attack identifies *Molybdenum*.

CHART 3

IDENTIFICATION OF LIGHT METALS AND ALLOYS (SPECIFIC GRAVITY 1.5 TO 3)



*THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-6

PROCEDURE FOR CHART 3

I LIGHT METALS AND ALLOYS, specific gravity 1.5 to 3-aluminum, magnesium and their light alloys. Consult chart 3.

A. ALUMINUM

1. Add a 0.5 percent solution of silver nitrate (39) and observe at the end of 1 minute.

2. No action indicates aluminum or a high-aluminum alloy.

3. Place 3 or 4 pellets of sodium hydroxide (54) on the specimen, add 3 or 4 drops of water, and allow to react for 1 minute. Then add a small crystal of ammonium persulfate (50).

a. A brown color identifies Alcoa 3S.

b. No color identifies *Alcoa 2S (aluminum).*

4. Place 3 or 4 pellets of sodium hydroxide (54) on the specimen, add 3 or 4 drops of water, and allow to react for 1 minute. Then add nitric acid (25) to dissolve the precipitate and, finally, add a few crystals of sodium bismuthate (52). A violet-brown color identifies *Manganese* as the alloying element.

5. Add cadmium chloride solution (15) and observe at the end of 2 minutes.

a. A dark spot identifies *Alcoa 75S, or* other alloys containing zinc.

b. No appreciable reaction identifies *Alcoa* 24S, *Alcoa 3S,* or other zinc-free alloys.

B. MAGNESIUM

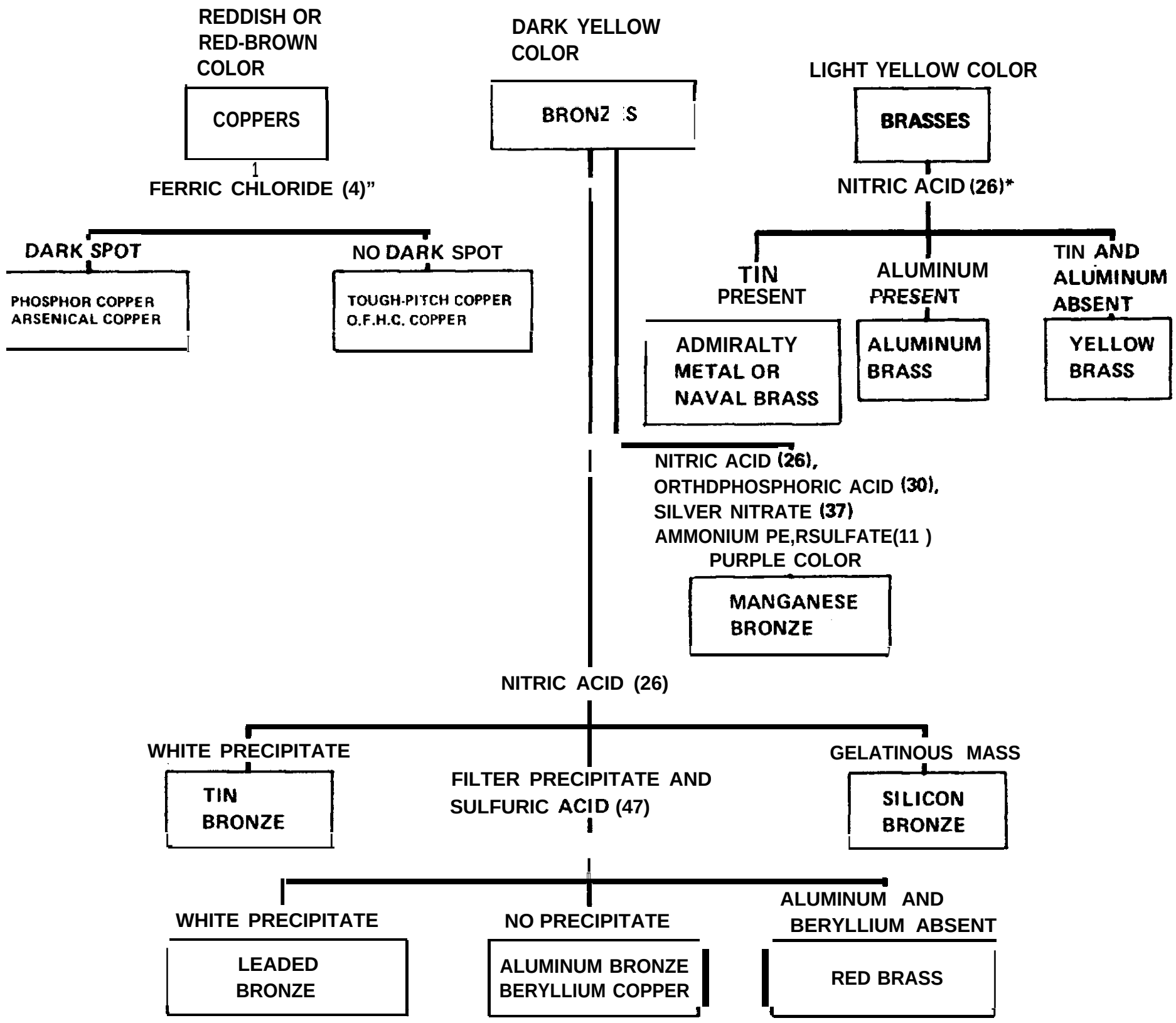
1. A black deposit of metallic silver forming immediately indicates magnesium or a high-magnesium alloy.

Immerse the metal in Chrome-Pickle (Dow No. 1 chemical treatment). *This* test is *recommended only when a freshly prepared solution is used and the operator is familiar with the colors of chemical treatment.*

2. A very bright brassy coating on the metal identifies the *aluminum-free* magnesium alloys such as *Dowmetal* M.

3. A grayish, iridescent coating on the metal identifies the aluminum-containing magnesium alloys such as *Dowmetal* C, H, FS, and others.

CHART 4
IDENTIFICATION OF COPPER AND COPPER ALLOYS*
(SPECIFIC GRAVITY 6 TO 9)



*-THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED TABLE IV-2

FIGURE IV-7

PROCEDURE FOR CHART 4

AVERAGE DENSITY METALS AND ALLOYS (specific gravity 6 to 9)—steels, irons, stainlees steels, stainless irons, copper alloys, nickel alloys, cadmium, tin, zinc and antimony,
Classify on the basis of color.

1. Reddish or red-brown-Copper.

2. Dark yellow—Bronzes.

3. Light yellow—Brasses.
Proceed according to color of material. Consult Chart 4.

4. White (magnetic and nonmagnetic)—Nickel, high-nickel alloys, copper-nickel alloys, nickel silvers, stainless steels, stainless irona, cadmium, tin, zinc and antimony.

5. White; or brown, if oxidized (magnetic and nonmagnetic)—Consult Charts 5A to 50.

A. REDDISH OR RED-BROWN-COPPER

Add acidified ferric chloride (4), react for 15 to 30 seconds, and wash with a fine stream of water.

1. A dark spot indicates phosphorus or arsenic is present. Identify by chemical analysis.

a The presence of phosphorus identifies Phosphor *Copper.*

b. The presence of arsenic identifies *Arsenical Copper.*

2. No dark spot indicates tough-pitch copper, or oxygen-free high-conductivity copper.

a. To differentiate between phosphorized and arsenical coppers, chemical analysis of spectrographic examination ia used. There are several methods of differentiating betwee tough-pitch and oxygen-free high-conductivity copper, all of which concern the detection of oxygen or cuprous oxide. Since this type of examination ia beyond the scope of the average scrap yard, it is suggested that this material be classified as Number 1 or Number 2 copper in accordance with the Specification Grades as indicated in Chapter VI, or in accordance with acceptable trade practices.

b. Copper-base alloys are so numerous and varied in chemical composition that there are few simple tests which can give reliable indications of all the alloying elements. Spot teata are leas reliable than spectrographic examination or chemical analysis because the intense blue color of the copper compounds tends to mask subsequent observations.

B. DARK YELLOW-BRONZES

Dissolve a small specimen in a beaker with 1:1 nitric acid (26) and boil.

1. A finely divided white precipitate identifies a *Tin-Bronze.*

2. A gelatinous mass identifies *a Silicon-Bronze.*

3. Filter the precipitate or gelatinous mass and add 1:1 sulfuric acid (47) to the filtrate.

a. A white precipitate forming on short standing identifies a *Leaded Bronze.*

b. No precipitate indicates a copper-beryllium alloy or aluminum bronze.

4. Dissolve approximately 0.5 gm. of a fresh specimen in a beaker with a mixture of 1:1 nitric acid (26) and 1:1 orthophoaphoric acid (30), dilute to 75 to 100 ml., and a few dropa of a 1 percent solution of silver nitrate (3'7) and 25 ml., of a 6 percent solution of ammonium persulfate (11), and boil.

A purple *color* identifies *Manganese Bronze.*

C. LIGHT YELLOW-BRASSES

1. Dissolve a small specimen in a beaker with 1:1 nitric acid (26) and bring to a boil.

2. A finely divided white precipitate of metaatannic acid shows that tin is present and that the material is probably *Admiralty Metal or Naval Brass.* Naval Brace has a darker yellow color than Admiralty Metal, due to the presence of beta phase in its structure.

3. In the absence of tin, a gelatinous precipitate of aluminum hydroxide obtained upon the addition of ammonia to a faint alkalinity identifies the material as aluminum brass, while a heavy white precipitate (lead sulfate) obtained upon the addition of sulfuric acid indicates free turning braas. To test for aluminum, take 2 or 3 drops of a mixture of 1:1 hydrochloric acid (20) and 1:1 nitric acid (26), Make alkaline with 1 ml. potassium hydroxide (35) and add 1 or 2 drops of alizarin S solution (5).

a. A red color identifies *Aluminum Brass.*

b. The absence of tin, aluminum, and lead identifies Yellow Brass (copper 65 to 75 percent).

CHART 5-A

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS (SPECIFIC GRAVITY 6 TO 9)

UNKNOWN

HYDROCHLORIC ACID (21)*
AND
POTASSIUM FERRICYANIDE (34)

DARK GREEN TO BLUE DROP

TYPE I Ni-RESIST	60 NICKEL-15 CHROMIUM
TYPE II Ni-RESIST	STAINLESS STEEL 330
TYPE V Ni-RESIST	STAINLESS STEEL 311
CAST I RON	STAINLESS STEEL 310
MANGANESE STEEL	STAINLESS STEEL 308
MILD STEEL	STAINLESS STEEL 347
LOW-ALLOY STEELS	STAINLESS STEEL 321
INVAR	STAINLESS STEEL 316
MI NOVAR	STAINLESS STEEL 304
Ni-SPAN C	STAINLESS STEEL 410
M-SPAN Hi	STAINLESS STEEL 420
Ni-SPAN Lo	STAINLESS STEEL 430
DURIMET K	STAINLESS STEEL 446
DURIMET T	Ni-HARD
INCOLOY	

SULFURIC ACID (46)

VIGOROUS GASSING, GREY OR BLACK SPOT

TYPE II Ni-RESIST
TYPE V Ni-RESIST
CAST IRON
MILD STEEL
MANGANESE STEEL
LOW-ALLOY STEELS
INVAR
MINOVAR
Ni-SPAN C
Ni-SPAN Hi
Ni-SPAN Lo
W-HARD
STAINLESS STEEL410
STAINLESS STEEL420

FOLLOW CHART 5B

SLIGHT OR NO REACTION

TYPE 1 Ni-RESIST
DURIMET K
DURIMET T
INCOLOY
50 NICKEL-15 CHROMIUN
STAINLESS STEEL 330
STAINLESS STEEL 311
STAINLESS STEEL 310
STAINLESS STEEL 306
STAINLESS STEEL 347
STAINLESS STEEL 321
STAINLESS STEEL 316
STAINLESS STEEL 304
STAINLESS STEEL 430
STAINLESS STEEL 446

FOLLOW CHART 5C

NO COLOR, RED, GREEN OR YELLOW-BROWN DROP

HASTELLOY A	NICKEL
HASTELLOY B	"D" NICKEL
HASTELLOY C	DURANICKEL
HASTELLOY D	PERMANICKEL
ILLIUM G	NICKEL SILVER (20% Ni)
ILLIUM R	NICKEL SILVER (18% Ni)
INCONEL	80 COPPER-20 NICKEL
INCONEL X	70 COPPER-30 NICKEL
NIMONIC 80	CONSTANTAN
MONEL	80 NICKEL-20 CHROMIUM
"R" MONEL	TIN
"K" MONEL	ZINC
"KR" MONEL	CADMIUM
"S" MONEL	ANTIMONY

NITRIC ACID (25)

GREY STAIN OR YELLOW DROP

HASTELLOY A

CLOUDY PEA-GREEN COLOR

HASTELLOY B
PERMANICKEL

FOLLOW CHART SD

TIN
ZINC
CADMIUM
ANTIMONY

FOLLOW CHART 5G

CLOUDY BLUE-GREEN COLOR

MONEL
'R" MONEL
"K" MONEL
'KR" MONEL
SO COPPER-20 NICKEL
70 COPPER-30 NICKEL
CONSTANTAN
NICKEL SILVER (20% Ni)
NICKEL SILVER (18% Ni)

FOLLOW CHART SE

CLEAR TO PALE-GREEN COLOR

NICKEL
"D" NICKEL
DURANICKEL

FOLLOW CHART 60

NO REACTION

HASTELLOY C
HASTELLOY D
ILLIUM G
ILLIUM R
INCONEL
INCONEL X
NIMONIC 80
80-NICKEL-20 CHROMIUM

FOLLOW CHART 5F

BLACK PRECIPITATE

"S" MONEL

● THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-B

CHART 5-B

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS

CONTINUED FROM CHART 5-A

VIGOROUS GASSING, GREY OR BLACK SPOT

TYPE II Ni-RESIST	MI NOVAR
TYPE V Ni-RESIST	Ni-SPAN C
CAST I RON	Ni-SPAN Hi
MANGANESE STEEL	Ni-SPAN Lo
MILD STEEL	STAINLESS STEEL 410
LOWALLOY STE ELS	STAINLESS STEEL 420
INVAR	M-HARD

MAGNETIC TEST

DEFINITELY MAGNETIC

TYPE V Ni-RESIST	Ni-SPAN C
CAST IRON	Ni-SPAN Lo
MILD STEEL	Ni-HARD
LOW-ALLOY STEELS	STAINLESS STEEL 410
1 NVAR	STAINLESS STEEL 420
MINOVAR	

PERCHLORIC ACID (32)*

GAS EVOLVED

CAST IRON
MILD STEEL
STAINLESS STEEL 410
STAINLESS STEEL 420
LOW-ALLOY STEELS

PERCHLORIC ACID (32)

CLOUDY GREEN DROP → CAST IRON

COLORLESS DROP → STAINLESS STEEL 410, STAINLESS STEEL 420, MILD STEEL, LOW-ALLOY STEELS

● *

NO GAS NO GAS EVOLVED

TYPE V Ni-RESIST
INVAR
MINOVAR
Ni-SPAN C
Ni-SPAN Lo
Ni-HARD

SULFURIC ACID (46) AND NITRIC ACID (25)

GREY STAIN → Ni-HARD

CLOUDY WHITE, YELLOW AND PINK DROPS → INVARAR, Ni-SPAN Lo

SULFURIC ACID (48]

CLOUDY PALE YELLOW DROP → INVAR

MOTTLED GREY AND WHITE DROP → Ni-SPAN Lo

NO REACTION → MINOVAR, Ni-SPAN C, TYPE V Ni-RESIST

SULFURIC ACID (46)

NO REACTION → Ni-SPAN C

BLACK DROP → TYPE V Ni-RESIST, MINOVAR

* *

NOT DEFINITELY MAGNETIC

TYPE II Ni-RESIST
MANGANESE STEEL
Ni-SPAN Hi

SULFURIC ACID (46)

VIGOROUS GASSING → MANGANESE STEEL

NO REACTION → Ni-SPAN Hi

BLACK DROP → TYPE II Ni-RESIST

● THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2
*"IDENTIFY AS DESCRIBED IN PROCEDURE FOR CHARTS 5-A THROUGH 5-G

FIGURE IV-9

CHART 5-C

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS

CONTINUED FROM CHART 5-A

SLIGHT OR NO REACTION

TYPE I Ni-RESIST	STAINLESS STEEL 309
DURIMET K	STAINLESS STEEL 347
DURIMET T	STAINLESS STEEL 321
INCOLOY	STAINLESS STEEL 316
60 NICKEL-16 CHROMIUM	STAINLESS STEEL 304
STAINLESS STEEL 330	STAINLESS STEEL 430
STAINLESS STEEL 311	STAINLESS STEEL 446
STAINLESS STEEL 310	

NITRIC ACID (26)'

VIGOROUS REACTION

TYPE I Ni-RESIST

NO REACTION

DURIMET K	STAINLESS STEEL 309
DURIMET T	STAINLESS STEEL 347
INCOLOY	STAINLESS STEEL 321
60 NICKEL-15 CHROMIUM	STAINLESS STEEL 316
STAINLESS STEEL 330	STAINLESS STEEL 304
STAINLESS STEEL 311	STAINLESS STEEL 430
STAINLESS STEEL 310	STAINLESS STEEL 446

HYDROCHLORIC ACID (19) ANO SULFUROUS ACID (49)

BLACK STAIN

DURIMET T
STAINLESS STEEL 316

NO BLACK STAIN

DURIMET K	STAINLESS STEEL 309
INCOLOY	STAINLESS STEEL 347
60 NICKEL-16 CHROMIUM	STAINLESS STEEL 321
STAINLESS STEEL 330	STAINLESS STEEL 304
STAINLESS STEEL 311	STAINLESS STEEL 430
STAINLESS STEEL 310	STAINLESS STEEL 446

MAGNETIC TEST

NOT DEFINITELY MAGNETIC

DURIMET K	STAINLESS STEEL 310
INCOLOY	STAINLESS STEEL 309
60 NICKEL-16 CHROMIUM	STAINLESS STEEL 347
STAINLESS STEEL 330	STAINLESS STEEL 321
STAINLESS STEEL 311	STAINLESS STEEL 304

DEFINITELY-MAGNETIC

STAINLESS STEEL 430
STAINLESS STEEL 446

HYDROCHLORIC ACID (20) AND POTASSIUM FERRICYANIDE (34)

GREEN SPOT

DURIMET K
INCOLOY
STAINLESS STEEL 304
STAINLESS STEEL 321
STAINLESS STEEL 347

WHITE DROP WITH BLACK EDGE

60 NICKEL-16 CHROMIUM
STAINLESS STEEL 330
STAINLESS STEEL 311
STAINLESS STEEL 310
STAINLESS STEEL 309

SULFUROUS ACID (49)

NO REACTION

60 NICKEL-15 CHROMIUM
STAINLESS STEEL 311
STAINLESS STEEL 310
STAINLESS STEEL 309

BLACK STAIN

STAINLESS STEEL 330

HYDROCHLORIC ACID (19) ANO CUPRIC CHLORIDE (3)

COPPER FLASH

SULFUROUS ACID (49)

TAN STAIN

STAINLESS STEEL 310

NO TAN STAIN

STAINLESS STEEL 309

POTASSIUM FERRICYANIDE (34)

DARK GREEN SPOT

STAINLESS STEEL 311

NO DARK GREEN SPOT

60 NICKEL-15 CHROMIUM

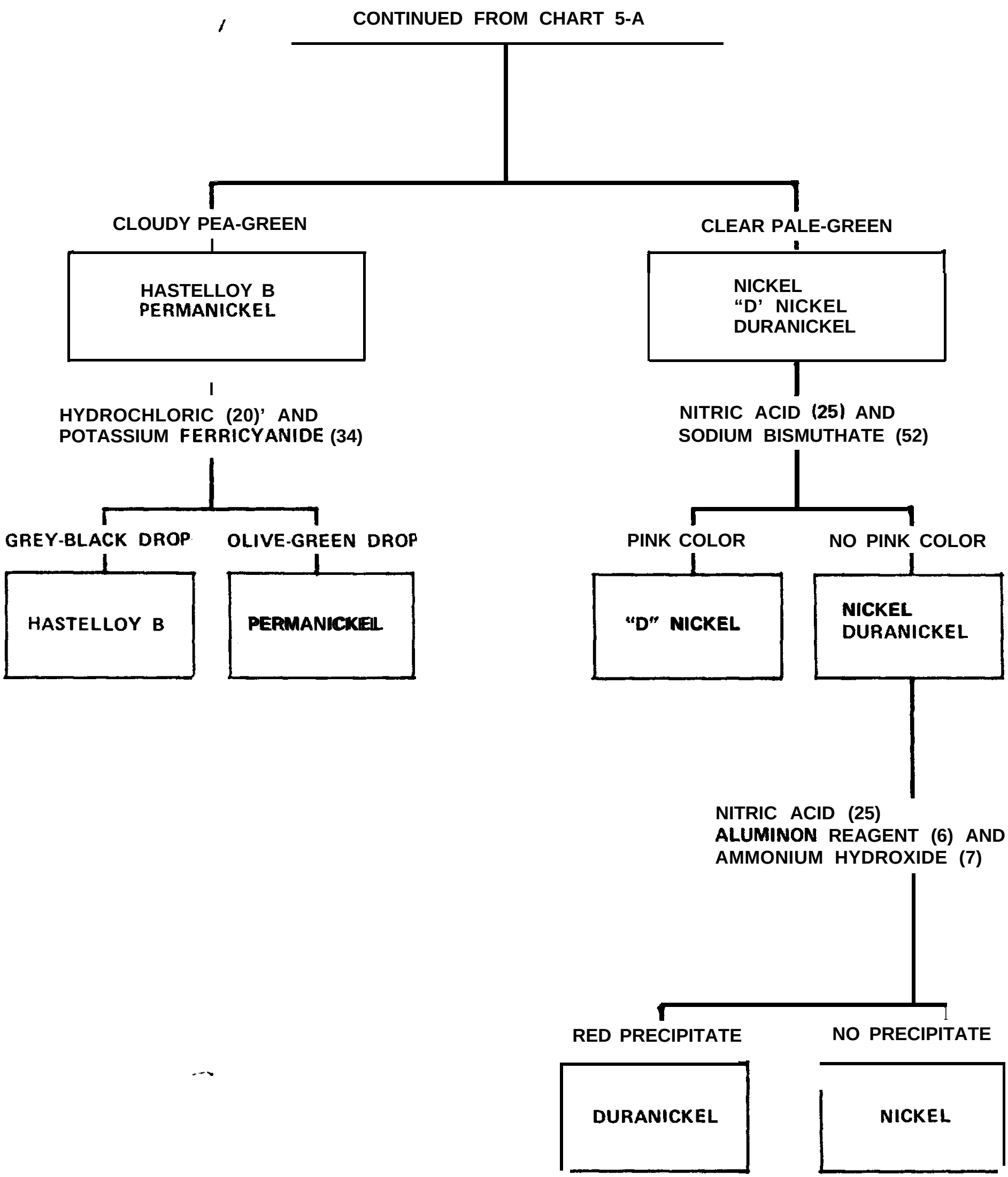
● THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED TABLE IV-2

*-IDENTIFY AS DESCRIBED IN PROCEDURE FOR CHARTS 6-A THROUGH 6-G.

FIGURE IV-10

CHART 5-D

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS



*THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-11

CHART 5-E

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS

CONTINUED FROM CHART 5-A

CLOUDY, BLUE-GREEN

MONEL	80 COPPER -20 NICKEL
"K" MONEL	70 COPPER -30 NICKEL
"R" MONEL	CONSTANTAN
"KR" MONEL	NICKEL SILVER (20% Ni)
	NICKEL SILVER (18% Ni)

1

NITRIC ACID (25)*

YELLOW-GREEN DROP → MONEL, "R" MONEL → NITRIC ACID (26) → GREY GREEN DROP → "R" MONEL; BRIGHT GREEN DROP → MONEL

DULL GREEN DROP → "KR" MONEL, NICKEL SILVER (20% Ni) → NITRIC ACID (26) → CLEAR DROP → "KR" MONEL; CLOUDY AQUA DROP → NICKEL SILVER (20% Ni)

CLEAR BLUE-GREEN → 80 COPPER -20 NICKEL, 70 COPPER -30 NICKEL, CONSTANTAN, NICKEL SILVER (18% Ni) → NITRIC ACID (26) → VIGOROUS GASSING → SLIGHT GASSING, COLORING DROP → CONSTANTAN

VIGOROUS GASSING → PALE, BLUE-GREEN DROP → 80 COPPER - 20 NICKEL, 70 COPPER - 30 NICKEL, NICKEL SILVER (18% Ni)

DULL DARK GREEN DROP WITH LIGHT GREEN PRECIPITATE → "K" MONEL

'THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2
'*IDENTIFY AS DESCRIBED IN PROCEDURE FOR CHARTS 5-A THROUGH 5-G

FIGURE IV-12

CHART 5-F

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS

CONTINUED FROM CHART 5-A

NO REACTION

HASTE LLOY C, HASTELLOY D, ILLIUM G, ILLIUM R, INCONEL, INCONEL X, NIMONIC 80, 80 NICKEL-20 CHROMIUM

HYDROCHLORIC ACID (19)*
SULFUROUS ACID (49), AND
POTASSIUM FERRICYANIDE (34)

- GREEN SPOT IN DROP: HASTELLOY C, HASTELLOY D, ILLIUM G, NIMONIC 80, ILLIUM R, INCONEL, INCONEL X
- YELLOW-BROWN DROP: 80 NICKEL - 20 CHROMIUM

HYDROCHLORIC ACID (19),
NITRIC ACID (25), AND
POTASSIUM FERRICYANIDE (34)

- DARK BROWN TO BLACK DROP: INCONEL, INCONEL X, ILLIUM G, ILLIUM R
- PALE GREEN AND YELLOW-BROWN DROP: HASTELLOY C, HASTELLOY D, NIMONIC 80

HYDROCHLORIC ACID (19)

- GAS EVOLVED: INCONEL, INCONEL X

HYDROCHLORIC ACID (19), SODIUM THIOSULFATE (45), AND POTASSIUM FERRICYANIDE (34)

- CLOUDY AQUA DROP: INCONEL
- CLOUDY DARK-GREEN DROP: INCONEL X

- NO GAS EVOLVED: ILLIUM G, ILLIUM R

PERCHLORIC ACID (32), NITRIC ACID (25), AND POTASSIUM FERRICYANIDE (34)

- YELLOW-BROWN DROP: ILLIUM R
- DARK GREEN TO BLACK DROP: ILLIUM G

NITRIC ACID (25)

- BLACK STAIN: HASTELLOY D
- NO STAIN: HASTELLOY C, NIMONIC 80

SULFURIC ACID (46), AND NITRIC ACID (25)

- NO GASSING: HASTELLOY C
- VIGOROUS GASSING: NIMONIC 80

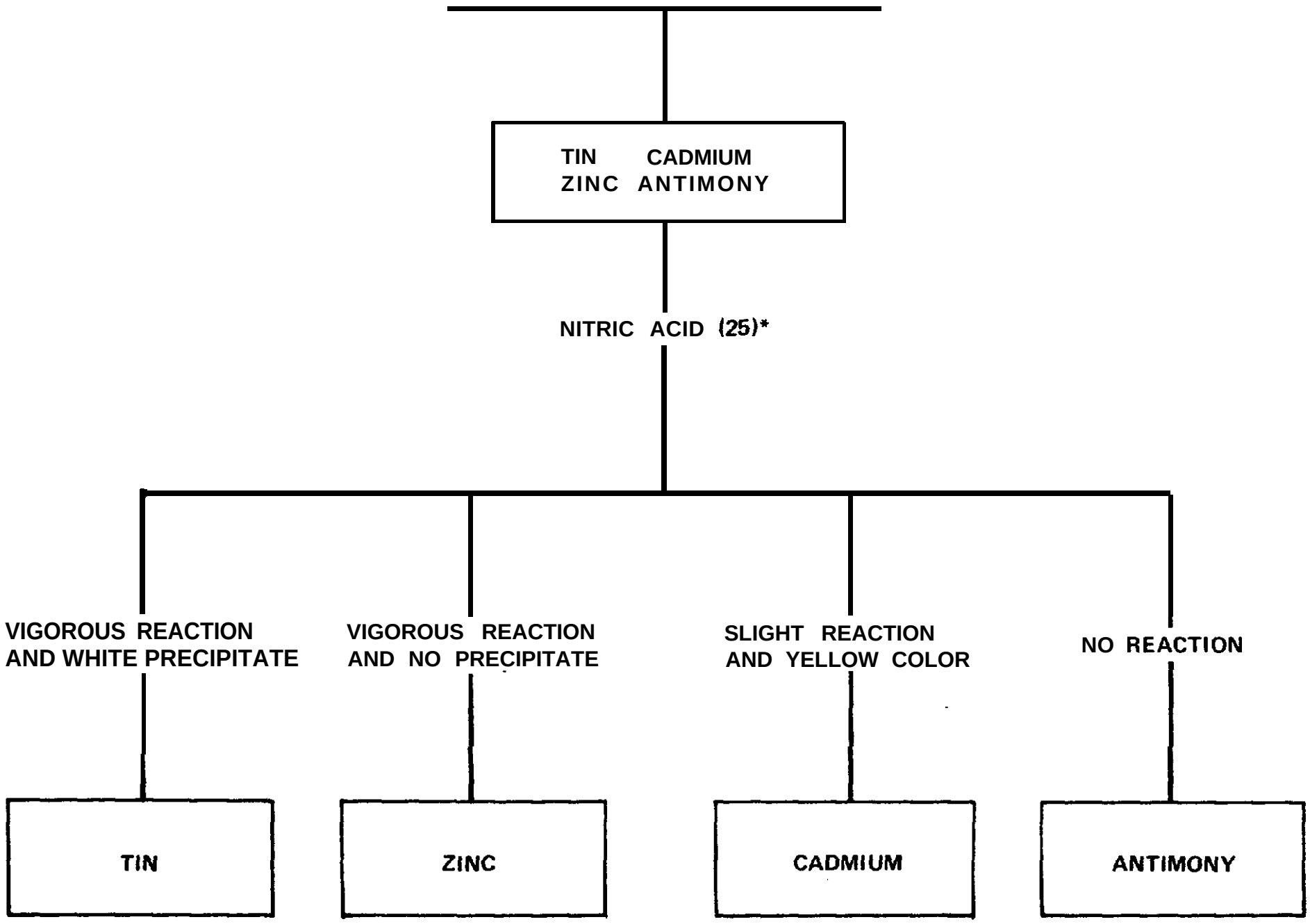
● THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-13

CHART 5-G

IDENTIFICATION OF FERROUS AND NONFERROUS METALS AND ALLOYS

CONTINUED FROM CHART 5-A



● THE FIGURE IN PARENTHESES REFERS TO THE REAGENT LISTED IN TABLE IV-2

FIGURE IV-14

PROCEDURE FOR CHARTS 5A THROUGH 5G

Consult Charts 5A through 5G.

A. WHITE AND OXIDIZED Nickel, high-nickel alloys, nickel silvers, cupro-nickels, stainless steel, tin, zinc, antimony, and cadmium, steels and cast irons. (Consult chart 5A.)

1. Add 10 percent hydrochloric acid (21) and allow to react for 1 minute. Then add 10 percent potassium ferricyanide (34) and observe at the end of 30 seconds.

a. A dark-green to blue drop indicates Type I Ni-Resist, Type II Ni-Resist, Type V Ni-Resist, cast iron, mild steel, manganese steel, low-alloy steels, Invar, Minovar, Ni-Span C, Hi-Span Hi, Ni-Span Lo, Ni-Hard, Durimet K, Durirnet T, 60 nickel—15 chromium, and stainless steels 330, 311, 310, 309, 304, 316, 321, 347, 410, 420, 430 and 446. Add sulfuric acid (46) and observe at the end of 1 minute.

b. Vigorous gassing, or a gray or black spot, indicates Type II Ni-Resist, Type V Ni-Resist, cast iron, mild steel, manganese steel, low-alloy steels, Invar, Minovar, Ni-Span C, Ni-Span Hi, Ni-Span Lo, Ni-Hard, and stainless steels 410 and 420. (Consult chart 5B.) Test with an Alnico magnet.

c. If the material is definitely magnetic, it may be Type V Ni-Reeist, cast iron, mild steel, low-alloy steels, Invar, Minovar, Ni-Span C, Ni-Span Lo, Ni-Hard, or stainless steels 410 and 420. Add perchloric acid (32) and observe at the end of 15 seconds.

d. Evolution of gas indicates mild steel, low-alloy steels, cast iron, or stainless steels 410 and 420.

2. Then add perchloric acid (32) to a fresh surface and observe at the end of 2 minutes.

a A cloudy green drop identifies *Cast Iron*.

b. A clear color drop identifies *MiLi Steel, Stainless Steel 410 or Stainless Steel 420.*

c. The chromium-containing stainless steels are considerably harder than mild steel and can be separated from mild steel by a hardness test. Identify the low-alloy steels by the spark test procedures or by one of the following testa.

(1) *Nickel*—React to completion with 1 or 2 drops of 1:1 nitric acid (26). Neutralize with a slight excess of zinc oxide (56). Add a few drops of standard dimethylglyoxime solution (17). A pink color identifies *Nickel. The* limit of detectability is 0.05 percent.

(2) *Chromium*—Mix equal volumes of potassium cobalticyanide (33), bromine water (14) end 20 percent sodium hydroxide (42). React to completion with a drop of the mixture and allow to dry. Gentle warming may be used to hasten drying. Repeat the procedure on a surface of known chromium content. Place a drop of diphenylcarbazide solution (18) on the dried spot. A more or less fugitive purple coloration identities *Chromium.* Comparison with the known sample indicates level of chromium present. Avoid contact of the akin with chemicals used in this test.

(3) *Molybdenum-React* to completion with 1 or 2 drops of 1:1 nitric acid (26). Remove reaction products with paper or cloth. React again with 1 drop of 20 percent sulfuric acid (48) and immerse a piece of falter paper saturated with a 10 percent solution of potassium ethyl xanthogenate (33). For molybdenum steels which are difficult to dissolve, react to completion with 3 dropa of 1:1 hydrochloric acid (20), neutralize with 1 drop of 20 percent sodium hydroxide (41), acidify with 1 drop of 20 percent sulfuric acid (48) and add a few xanthogenate crystals (51). A red color identifies Molybdenum. The limit of detectability is 0.1 percent.

(4) *Vanadium-React* to completion with 1 or 2 drops of 1:1 nitric acid (26). Add 1 drop of orthophosphoric acid (29), a small crystal of sodium fluoride (53) if titanium is present, and then 1 drop of a 3 percent solution of hydrogen peroxide (23). A reddish-brown color identifies *Vanadium. The* limit of detectability is 0.1 percent. As an alternate, react with 1:1 nitric acid (26), neutralize with 1 drop of a 40 percent solution of sodium hydroxide (40), acidify with 1 drop of 1:1 acetic acid (2), and add 1 drop of 1,8-oxyquinoline (31). A greenish-black to black color identifies *Vanadium. The* limit of detectability is 0.2 percent.

(5) *Silicon*—React to completion with 1 or 2 drops of hydrochloric acid (19) and add 1 drop of water. White particles, which rise to the surface in the form of a yellowish

foam, indicate silicon. Then add 1 drop of 2 Molar sodium hydroxide solution (42), acidify with 1 drop of 1:1 hydrochloric acid (20), and add 1 drop of ammonium molybdate solution (8). A yellow color which forms slowly indicates silicon. Then add 1 drop of a solution containing 0.05 g. of benzidine hydrochloride (14). A blue color identifies *Silicon. The* limit of detectability is 0.3 percent.

(6) *Aluminum*—React to completion with 2 or 3 drops of a mixture of 1:1 hydrochloric acid (20) and 1:1 nitric acid (26). Make alkaline with 1 Molar potassium hydroxide (35) and add 1 or 2 drops of alizarin S solution (5). A red color indicates aluminum. Beryllium and copper form a red color also. Add a few drops of 1:1 acetic acid (2) to dissolve beryllium and copper. If the red color remains, *Aluminum is confirmed. The* limit of detectability is 0.02 percent.

B. No evolution of gee indicates Type V Ni-Resist, Invar, Minovar, Ni-Span C, Ni-Span Lo, or Ni-Hard. Add 2 drops sulfuric acid (46), 1 drop nitric acid (25), and observe at the end of 2 minutes.

1. A gray stain identifies *Ni-Hard.*

2. A cloudy, white, yellow and pink color indicates Invar or Ni-Span Lo. Add sulfuric acid (46) and observe at the end of 3 minutes.

a A cloudy, pale yellow drop identifies *Invar.*

b. A mottled gray and white drop identifies *Ni-Span Lo.*

3. No reaction indicates Type V Ni-Resist, Minovar or Ni-Span C. Add sulfuric acid (46) and observe at the end of 1 minute.

a No reaction identifies *Ni-Span C*

b. A black color indicates Type V Ni-Resist or Minovar.

C. Identify *Type V Ni-Resist* and *Minovar* by chemical or spectrographic analysis. Or, immerse a known specimen of one alloy and the unknown specimen in 20 percent sulfuric acid (43) and connect them to the terminals of a O-1 milliammeter. No permanent deflection of the ammeter needle identifies the known and unknown specimens as the same alloy a permanent deflection of the needle identifies the unknown specimen as a different alloy than the known specimen.

1. If the material is not definitely magnetic, it maybe Type II Ni-Resist, manganese steel or Ni-Span Ni. Add sulfuric acid (46) and observe at the end of 15 seconds.

a Vigorous gassing identifies *Manganese Steel.*

b. A black drop identifies *Type II Ni-Resist.*

c. No reaction identities *Ni-Span Hi.*

2. No reaction, or a slight reaction, indicates Type I Ni-Resist, Durimet K, Durimet T, 60 Nickel—15 chromium and stainless steels 330, 311, 310, 309, 304, 316, 321, 347, 430, 446. (Consult Chart 5C.) Add 1:1 nitric acid (26) and observe at the end of 15 seconds.

a A vigorous reaction identifies *Type I Ni-Resist.*

b. No reaction indicates Durimet K, Durimet T, 60 nickel-15 chromium, and stainless steels 330,311, 310,309,304,316, 321, 347,430, and 446. Add hydrochloric acid (19) and allow to react for 1 minute. Then add 6 percent sulfurous acid (49) and observe at the end of 30 *seconds.*

c. A black stain indicates Durimet T or stainless steel .316.

(1) Identify Durimet T and stainless steel 316 by chemical or spectrographic analysis. Or, (see paragraph Cabove) by the use of a milliammeter, using 10 percent hydrochloric acid (21) instead of 20 percent sulfuric acid (48).

(2) The absence of a black stain indicates Durimet K Incoloy, 60 nickel-15 chromium, or stainless steels 330, 311, 310, 309, 304, 321, 347, 430 and 446. Test with an Alnico magnet.

(3) If the material is definitely magnetic, it is Stainless *Steel 430* or Stainless *Steel 446.*

(4) If the material is not definitely magnetic, it may be Durimet K, Incoloy, 60 nickel—15 chromium, or stainless steels 330, 311, 310, 309, 304, 321, or 347. Add 1:1 hydrochloric acid (20), allow to react, and add 1 drop of 10 percent potassium ferricyanide (34).

(5) A green spot indicates Durimet K, Incoloy, stainless steels 304,321 or 347.

(a) Identify *Durimet K* by the presence of copper on chemical or spectrographic analysis.

(b) Identify *Incoloy* by determination of nickel on chemical or spectrographi analysis.

(c) Identify Stainless *Steel* 30.4 by the absence of titanium and columbium on chemical or spectrographic analysis.

(d) Identify Stainless *Steel 321* by the presence of titanium on chemical or spectrographic analysis.

(e) Identify *Stainless Steel 347* by the presence of columbium on chemical or spectrographic analysis.

(6) A white drop with a black edge indicates 65 nickel–15 chromium, or stainless steels 330, 311, 310 or 309. Add 6 percent sulfurous acid (49) to a fresh surface and observe at the end of 1 minute.

(a) A black stain identifies *Stainless Steel 330.*

(b) No reaction indicates. 60 nickel–15 chromium, or stainless steels 311,310 or 309. The following procedures will give positive results only when the alloys contain no precipitated carbides and are in the same annealed or cold-worked condition. Add 1 drop of hydrochloric acid (19) and 1 drop of acidified cupric chloride (3) to a fresh surface and observe at the end of 1 minute.

(c) A cower flash indicates stainless steels 310 or 309. Add hydrochloric acid (19), sulfuric acid (46) and 6 per cent sulfurous acid (49), and observe at the end of I minute.

(d) A tan stain identities *Stainless Steel 310.*

(e) No tan stain identifies *Stainless Steel 309.*

(f) *No* copper flash indicates *Stainless Steel 311 or 60* nickel–15 chromium. Add 20 percent sulfuric acid (48) and a drop of 10 percent potassium ferricyanide (34) and observe at the end of 1 minute.

(g) A dark green spot identifies *Stainless Steel 311.*

(h) No dark green spot identifies 60 *Nickel—15 Chromium.*

d. A red, green or yellow-brown drop, or no color, indicates Hastelloy A, Hastelloy B, Hastelloy C, Hastelloy D, Illium G, Illium R, Inconel, Inconel X, Nimonic 80, Monel, "K" Monel, "R' Monel, "KR" Monel, "S" Monel, Nickel, "D" Nickel, Duranickel, Permanickel, Nickel Silver (20% Ni), Nickel Silver (18% Ni), 80 copper-20 nickel, 70 copper-30 nickel, Constantan, 80 nickel-20 chromium, tin, zinc, cadmium and antimony. (Consult Chart 5A.) Add nitric acid (25) and observe at the end of 1 minute.

(1) A gray stain and yellow color identifies *Hastelloy A.*

(2) A black precipitate identifies "S" *Monel.*

e. A cloudy, pea-green color indicates Hastelloy B or Permanickel. (Consult Chart 5D). Add 1:1 hydrochloric acid (20) and allow to react for 1 minute. Then add 10 percent potassium ferricyanide (34) and observe at the end of 1 minute.

(1) A gray-black drop identifies *Hastelloy B.*

(2) An olive-green drop identifies *Permanickel.*

f. A clear, pale green colored drop indicates nickel, "D' Nickel, or Duranickel. (Consult Chart 5D.) Add nitric acid (25) and allow to react for 1 minute. Then add a drop of water and a few crystals of sodium bismuthate (52). Stir and observe at the end of 30 seconds.

(1) A pink color identifies *"D" Nickel.*

(2) The absence of color indicates nickel or Duranickel. Add nitric acid (25) and allow to react *for* 1 minute. Then add 1 drop of aluminun reagent (6) and 3 *drops of* ammonium hydroxide (7). Stir and observe at the end of 5 seconds.

(a) A red precipitate identifies *Duranickel.*

(b) No precipitate identities *Nickel.*

g. A cloudy, blue-green color indicates "K" Monel, Monel, "R" Monel, "KR" Monel, 80 copper-20 nickel, 70 copper-30 nickel, constantan, nickel silver (20% nickel) or nickel silver (18% nickel). (Consult Chart 5E.) Add nitric acid (25) and observe at the end of 5 minutes.

(1) A dull, dark-green *color* with a light-green precipitate identities "K" *Mend*

(2) A dull, green color indicates nickel silver (20% Nickel) or "KR" Monel. Add 1:1 nitric acid (26) and observe at the end of 10 seconds.

(a) A clear drop identifies *"KR" Monel.*

(b) A cloudy aqua drop identifies Nickel *Silver (20% Nickel).*

(3) A yellow-green color indicates Monel or "R' Monel. Add 1:1 nitric acid (26) and observe at the end of 8 minutes.

(a) A bright green color identifies *Monel.*

(b) A grey-green color identifies *"R" Monel.*

(4) A clear, blue-green color indicates nickel silver (18% Ni), 80 copper-20 nickel, 70 copper-30 nickel or Constantan. Add 1:1 nitric acid (26) and observe at the end of 5 seconds.

(a) Slight gassing and a colorless drop identifies *(55 Copper—45 Nickel) Constantan.*

(b) Vigorous gassing and a pale, blue-green drop indicate nickel silver (18% nickel), 80 copper-20 nickel, or 70 copper-30 nickel.

(c) Identify *Nickel Silver (18% nickel), 80 Copper 20 Nickel,* and 70 *Copper—30 Nickel* by chemical or spectrographic analysis.

h. No reaction indicates Hastelloy C, Hastelloy D, Illium G, Illium R, Inconel, Inconel X, Nimonic 80, and 80 nickel—20 chromium. (Consult Chart 5F.) Add hydrochloric acid (19), 1 drop of 6 percent sulfurous acid (49), and allow to react for 1 minute. Then add 1 drop 10 percent potassium ferricyanide (34) and observe at the end of 1 minute.

(1) A yellow-brown drop identifies 80 *Nickel—20 Chromium Alloy.*

(2) A green drop indicates Hastelloy C, Hastelloy D, Illium G, Illium R, Inconel, Inconel X and Nimonic 80. Add hydrochloric acid (19), nitric acid (25) and allow to react for 1 minute. Then add 10 percent potassium ferricyanide (34) and observe after 1 minute. A dark brown to black color indicates Inconel, Inconel X, Illium G, or Illium R. Add hydrochloric acid (19) and observe at the end of 10 seconds.

(3) If gas is evolved, the material is Inconel *or* Inconel X. Add another drop of hydrochloric acid (19) and allow to react for 1 minute. Then add 1 drop of sodium thiosulfate (45) and allow to react for 1 minute. Finally, add 1 drop of potassium ferricyanide (34), stir, and observe at the end of 5 minutes.

(u) A cloudy, aqua drop identifies *Inconel.*

(b) A cloudy, dark-green drop identifies *Inconel X.*

(4) If no gas is evolved, the material is Illium G or Illium R. Add perchloric acid (32), nitric acid (25) and allow to react for 1 minute. Then add 1 drop 10 percent potassium ferricyanide (34), and observe at the end of 1 minute.

(a) A yellow-brown colored drop identities *Illium R.*

(b) A dark green to black colored drop identifies *Illium G.*

(5) A pale green and yellow-brown drop indicates Hastelloy C, Hastelloy D or Nimonic 80. Add nitric acid (25) and observe at the end of 1 minute.

(a) A black stain identifies *Hastelloy D.*

(b) No stain indicates Hastelloy C or Nimonic 80.

(6) Add sulfuric acid (46) and nitric acid (25) and observe at the end of 5 seconds.

(a) *Vigorous* gassing identifies *Nimonic 80.*

(b) No gassing identifies *Hastelloy C*

i. If the material is known to be tin, zinc, antimony or cadmium, place it in nitric acid (25), in a test tube and observe at the end of 1 minute. (Consult Chart 5G.)

(1) A vigorous reaction and a white precipitate identifies *Tin.*

(2) A vigorous reaction and no precipitate identifies *Zinc.*

(3) A slight reaction and a yellow-colored solution identifies *Cadmium.*

(4) No reaction identifies *Antimony.*

5. *Chemical Testing (see* Table IV-2).

a. Spot test kits for general use in the scrap yard contain reagents which are capable of identifying the most common metals in scrap yards. These reagents include concentrated acids which are very dangerous. When using reagents the following precautions should be followed:

(1) Ensure work area is well ventilated.

(2) Safety glasses or a safety shield should be worn to protect face and eyes.

(3) Cotton or rubberized gloves will protect skin from immediate contact with corrosives.

(4) Whenever possible use the test kit where an emergency eyewash is immediately available.

(5) When a test solution is spilled onto the skin or protective clothing, wash the area thoroughly for 5 minutes. Skin damage can occur over a period. of time and may not be immediately noticeable or painful.

(6) Prevent dangerous chemical reactions by always slowly pouring chemicals into water. Never pour water into concentrated chemicals as this can cause extremely dangerous high heat reactions resulting in splashing and burns.

(7) Always wash face and hands after working with chemicals. This helps reduce the possibility of skin irritation or dermatoses.

b. The reagenta most commonly used in chemical testing include

(1) Nitric acid, concentrated (HNO_3). Sp. gr. 1.42.

(2) Hydrochloric acid, concentrated (HCl). Sp. gr. 1.18.

(3) Silver nitrate solution (0.5 percent $AgNO_3$, 100 ml. I-LO).[1] Dissolve 0.5 gram of silver nitrate, into 100 ml. of water.

(4) Potassium ferricyanide solution (10 percent $K_3Fe(CN)_6$, in I-LO). [1] Dissolve 10 gram of potassium ferricyanide in 100 ml. of water.

(5) Ammonium hydroxide, concentrated (NH_4OH). Sp. gr. 0.9.

(6) Solution B,[2] prepared as follows

(a) Dissolve 1 gram dimethylglyoxime in 50 ml. acetic acid (glacial). (See Table IV-2.)

(b) Add 10 ml. distilled water and 30 ml. NILOH concentrated ammonium hydroxide solution, then stir until all salts are in solution.

(c) Add 10 gram ammonium acetate.

c. Before applying any of the above reagents,[3] the surface of the sample must be cleaned with a file or a grinding wheel. It is also essential to apply reagents in the correct order. In certain instances, observation of the reaction speed is aa vital to the chemical test as is recognition of colors and color combinations.

d. Solution B and other required acids, salts and reagents should be prepared by the DoD host laboratory or any other nearby Government laboratory-or they may be procured from private sector pharmacies, hospitals or chemical laboratoties.

e. None of the above' chemicals are listed in the hazardous materials table (40 CFR 261.33(e) and (f)) aa hazardous wastes. Landfill disposal through existing service contracts is recommended.

[1] This reagent, which has a safe shelf life of only 4 to 6 months, muet be stored in opaque plastic bottles to prevent decomposition from exposure to light

[2] The American Society of Testing Materials (ASTM) suggests that this solution be ueed in conjunction with other acids when testing for nickel in alloys. Alloys containing nickel will produce a pink *or red* color when added to sample after other acids have been applied.

[3] Since these magenta have limited shelf lives when exposed to air, light and temperature changes, they should be replaced when spot tests on known samples fail to yield expected results.

Table IV-2. Reagents and Testing Solutions

(Note: Use only freshly prepared solutions using distilled water as solute or solvent as appropriate.)

1. Acetic acid, concentrated (glacial)	Sp. gr. 1.049
2. Acetic acid, 1:1	Add 50 ml. of glacial acetic acid to 50 ml. of water.
3. Acidified cupric chloride	Dissolve 10 g. of cupric chloride in 10 ml. of concentrated hydrochloric acid and dilute to 100 ml.
4. Acidified ferric chloride	Dissolve 10 g. of ferric chloride in 10 ml. of concentrated hydrochloric acid and dilute to 100 ml.
5. Alizarin S	Dissolve 0.1 g. of Alizarin Sin 100 ml. of water.
6. Aluminon reagent	Dissolve 0.1 g. of Aluminon in 100 ml. of water.
7. Ammonium hydroxide, concentrated	Sp. gr. 0.9.
8. Ammonium molybdate	Dissolve 5 g. of ammonium molybdate in 35 ml. of 1:2 nitric acid and dilute to 100 ml.
9. Ammonium oxalate, saturated	Prepare a saturated solution of ammonium oxalate in water.
10. Ammonium persulfate*	Prepare a saturated solution of ammonium persulfate in water.
11. Ammonium persulfate* 6 percent	Dissolve 6 g. of ammonium persulfate in 100 ml. of water.
12. Ammonium sulfide*	Prepare a saturated solution of hydrogen sulfide in 1:9 ammonium hydroxide.
13. Aqua regia*	Mix 3 volumes of hydrochloric acid and 1 volume of nitric acid.
14. Benzidine hydrochloride	Dissolve 0.05 g. of benzidine hydrochloride in 10 ml. of glacial acetic acid and dilute to 100 ml.
15. Cadmium chloride	Dissolve 5 g. of cadmium sulfate and 3 g. of sodium chloride in 5 ml. of hydrochloric acid and dilute to 100 ml.
16. Chrome pickle*	Dow number 1 chemical treatment.
17. Dimethylglyoxime	Prepare a saturated solution of dimethylglyoxime in 100 ml. of 95 percent ethyl alcohol.
18. Diphenylcarbazide	Dissolve 1 g. of diphenylcarbazide in 100 ml. of 95 percent ethyl alcohol.
19. Hydrochloric acid, concentrated	Sp. gr. 1.18.
20. Hydrochloric acid, 1:1	Add 50 ml. of concentrated hydrochloric acid to 50 ml. of water.
21. Hydrochloric acid, 10 percent	Dilute 8 ml. of concentrated hydrochloric acid to 100 ml. of water.
22. Hydrofluoric acid, concentrated	48 percent.
23. Hydrogen peroxide, 3 percent	Dilute 10 ml. of 30 percent hydrogen peroxide to 100 ml. of water.
24. Mercuric chloride, 10 percent	Dissolve. 10 g. of mercuric chloride in 100 ml. of water.
25. Nitric acid, concentrated	Sp. gr. 1.42.
26. Nitric acid, 1:1	Add 50 ml. of concentrated nitric acid to 50 ml. of water.
27. Nitric acid, 1:2	Add 33 ml. of concentrated nitric acid to 67 ml. of water.
28. p-nitrobenzene-azo-alpha-naphthol	Dissolve 0.001 g. of p-nitrobenzene-azo-alpha-naphthol in 100 ml. of 1 M sodium hydroxide.
29. Orthophosphoric acid, concentrated	85 percent.
30. Orthophosphoric acid, 1:1	Add 50 ml. of concentrated orthophosphoric acid to 50 ml. of water.
31. 1,8-oxyquinoline	Dissolve 2.5 g. 1,8-oxyquinoline in 6 ml. of glacial acetic acid and dilute. to 100 ml.
32. Perchloric acid, concentrated	70 percent.
33. Potassium ethyl xanthogenate	Dissolve 10 g. of potassium ethyl xanthogenate in 100 ml. of water.
34. Potassium ferricyanide, 10 percent	Dissolve 10 g. of potassium ferricyanide in 100 ml. of water.
35. Potassium hydroxide, 1 Molar	Dissolve 5.6 g. of potassium hydroxide in 100 ml. of water.
36. Silver nitrate, 2 percent	Dissolve 2 g. of silver nitrate in 100 ml. of water.
37. Silver nitrate, 1 percent	Dissolve 1 g. of silver nitrate in 100 ml. of water.

Table IV-2. **Reagents and Testing** Solutions-Continued

(Note: Use only freshly prepared solutions using distilled water as solute or solvent as appropriate.)

38. Silver nitrate, 0.5 percent	Dissolve 0.5 g. of silver nitrate in 100 ml. of water.
39. Silver nitrate, 0.2 percent	Dissolve 0.2 g. of silver nitrate in 100 ml. of water.
40. Sodium hydroxide, 40 percent	Dissolve 40 g. of sodium hydroxide in 100 ml. of water.
41. Sodium hydroxide, 20 percent	Dissolve 20 g. of sodium hydroxide in 100 ml. of water.
42. Sodium hydroxide, 2 Molar	Dissolve 8 g. of sodium hydroxide in water and dilute to 100 ml.
43. Sodium hydroxide, 1 Molar	Dissolve 4 g. of sodium hydroxide in water and dilute to 100 ml.
44, Sodium peroxide, 40 percent	Dissolve 40 g. of sodium peroxide in' 100 ml. of water.
45. Sodium thiosulfate	Dissolve 25 g. of sodium thiosulfate in 100 ml. of water.
46. Sulfuric acid, concentrated	Sp. gr. 1.84.
47. Sulfuric acid, 1:1	Add 50 ml. of concentrated sulfuric acid to 50 ml. of water.
48. Sulfuric acid, 20 percent	Add 20 ml. of concentrated sulfuric acid to 80 ml. of water.
49. Sulfurous acid, 6 percent*	Saturate 100 ml. of water at room temperature with sulfur dioxide,

Reagents-Salts

50. Ammonium persulfate
51. Potassium ethyl xanthogenate
52. Sodium bismuthate
53. Sodium fluoride
54. Sodium hydroxide
55. Sodium nitrate
56. Zinc oxide

* Use freshly prepared solution.

D. LABORATORY ANALYSIS OF METALLIC SCRAP

1. The following paragraphs describe more sophisticated spot testing procedures which can be used when the simplified procedures outlined in paragraph C, above, will not provide adequate identification of metallic scrap (particularly that which may have a high market value). It will seldom be necessary to follow every step in these procedures since a general familiarity with metals, and with the procedures outlined below, will enable qualified technicians to eliminate many materials from consideration before testing is begun. It must be emphasized that these procedures are qualitative only. Quantitative information must be obtained by more detailed spectrographic or chemical analyses.

2. Table IV-2 lists some reagents and testing solutions used in making chemical analyses of metallic scrap. Occasionally, one or more drops of the reagent will not provide a sufficient reaction to be detectable by visual examination. In these cases, use several drops, absorb the reaction products in a piece of filter paper, and then drop the identifying reagent on the filter paper; or, the sample may be dissolved by acid in a beaker and the reagent added to this solution.

3. Before making chemical tests, clean the specimen with a decreasing solvent, stone wheel, emery cloth, sandpaper, or a file to remove dirt, grease, corrosion products, or any metallic plating or wash (e.g., zinc, tin, cadmium, nickel, chromium, gold, or silver).

4. Known samples of materials may be tested simultaneously with the unknown to compare their behaviors under test conditions. To avoid errors resulting from the heat generated by some chemical reactions, samples less than 0.02 inch thick should always be placed on a metal slab during testing.

5. Test Procedures.

a. Tests for High-grade Bronze ("M" metal):

(1) High-grade bronze is a dark yellow metal of medium weight. It is nonmagnetic and nonsparking.

(2) Grind or file a clean surface on the sample.

(3) Apply one drop of 0.5 percent solution of silver nitrate to the freshly exposed surface.

(4) A clear color or a gray color slowly developing on the surface indicates "M" metal (high-grade bronze).

b. Test for Red or Composition Brass.

(1) Red brass is a light yellow metal of medium weight. It is nonmagnetic and nonsparking.

(2) Grind or file a clean surface on the sample.

(3) Apply one drop of 0.5 percent solution of a silver nitrate to the freshly exposed surface.

(4) A spontaneous gray-black or black color developing on the surface indicates red or composition brass.

c. Tests for Yellow Brass.

(1) Yellow brass is a light yellow metal of medium weight. It is nonmagnetic and nonsparking.

(2) File a niche in the metal or grind a clean surface. Yellow brass is identifiable by its yellow color.

d. Tests for Manganese Bronze.

(1) Manganese bronze is a light yellow metal of medium weight. It is slightly magnetic but nonsparking.

(2) Manganese bronze shows the same yellow color in the freshly filed surface as yellow brass.

(3) Due to the high iron content in its alloy (about 31/2 percent), manganese bronze is easily separated from yellow brass by testing the filings. Magnetic filings from a light yellow metal indicate manganese bronze. The filings will congregate around the lines of force emanating from the magnet.

e. Tests for Silicon Bronze and Aluminum Bronze.

(1) Silicon and aluminum bronzes are dark yellow metals of medium weight. Both metals are slightly magnetic and nonsparking.

(2) Silicon bronze will develop a reddish-yellow color on the surface of the casting due to its high copper content of 82 to 97 percent. A small sample of silicon bronze placed into a beaker containing concentrated nitric acid will, upon completion of the reaction, reveal a viscous or gelatinous substance remaining in the solution.

(3) Aluminum bronze has a light yellow color on its surface and a darker yellow color on the surface of a fresh cut. The freshly ground or cut surface of aluminum bronze will reveal a color similar to that of red brass instead of a yellow color as noted in manganese bronze. It is in the color of a freshly exposed surface that will be found the distinguishing characteristic which separates aluminum from manganese bronze since filings from both of these metals are attracted to the magnet. Aluminum bronze, unlike silicon bronze, does not develop a jellied mass when dissolved in a beaker of nitric acid.

f. Tests for Monel, Nickel-silver (German-silver) or Cupro-nickel.

(1) These three metals belong to the copper-containing white metal group and are of medium weight. Grind or file a fresh surface to note if the metal is white. Do not allow these metals to become overheated from the grinding wheel. Heat accelerates their reaction to acids.

(2) Apply one drop of concentrated nitric acid to a freshly ground surface. The more copper in the alloy, the faster the reaction will be to the acid, so that it is important to note the speed of the reaction as described below:

(a) Monel, regular, magnetic (7o percent nickel and 30 percent copper) and "K" Monel, nonmagnetic (64 percent nickel, 30 percent copper and 4 percent aluminum) will slowly develop a milky green color in solution.

(b) Nickel-silver, normally nonmagnetic (60 percent copper, 20 percent nickel and 20 percent zinc) will immediately develop a blue-green color in solution and give forth a puff of smoke due to the zinc content. Wash off the nitric acid with water and observe surface. If a copper or pink color develops on surface after rinsing in water, the sample is nickel-silver (German-silver).

(c) Cupro-Nickel, nonmagnetic, (70 percent copper, 30 percent nickel) rapidly develops a blue-green color in the solution due to a greater copper content than that of monel. Cupro-nickel does not develop a copper or pink color on its surface when rinsed with water and this helps to distinguish this alloy from the nickel-silvers (German-silver).

(3) Additional test methods for separating monel, nickel-silver, and cupro-nickel.

(a) Spark Test.

1. Monel (regular or "K") imparts short red sparka in the carrier lines.

2. Cupro-nickel imparts short red sparks in the carrier lines but pressure must be maintained against the grinding wheel in order to continue revealing sparks.

3. Nickel-silver, normally, does not spark.

(b) Chemical Test.

1. Apply one drop of concentrated nitric acid to freshly filed surface; if a green or blue-green color develops in the solution, note the speed of reaction which will determine the likely copper content. These colors developing on a white metal from nitric acid indicate copper is contained in the alloy.

2. Add one drop of hydrochloric acid to sample.

3. Add one or two drops of Solution B. A red color developing in solution confirms the presence of nickel and identifies the sample as being a nickel-copper (Monel) or copper-nickel (cupro-nickel, nickel-silver) alloy since copper was confirmed by the nitric acid.

g. Tests for Nickel:

(1) Nickel is white in color, of medium weight and strongly magnetic. Nickel imparts very short red sparks in the carrier lines when applied to a grinding wheel.

(2) File or grind a clean surface. Apply one drop of nitric acid to the clean surface. A pale green color developing very slowly in solution identifies a likelihood of nickel.

(3) To establish definite proof of nickel in conjunction with the magnet and spark testa, add one drop of hydrochloric acid to the nitric acid, then one or two drops of Solution B. A red color appearing in solution confirms nickel.

h. Tests for Zinc.

(1) Zinc is a bluish-gray metal of medium weight. It is nonmagnetic and nonsparking.

(2) Zinc reacts vigorously in nitric acid evolving very acrid fumes and a brown color. A small sample or filings dropped into a Pyrex beaker containing nitric acid reacts violently, completely dissolving the sample or filings. There will be no precipitate remaining in solution.

i. Tests for Tin.

(1) Tin is a white metal of medium weight. It is nonmagnetic and nonsparking.

(2) Tin filings also react vigorously in nitric acid with almost the same acrid fuming and brown color effect as zinc. Tin, however, does not dissolve in nitric acid but forms a massive white spongy-looking precipitate in the beaker glass upon completion of the reaction.

j. Tests for Magnesium:

(1) Magnesium is a white metal, very light in weight, and is nonmagnetic and nonsparking. This metal is one-third lighter in weight than aluminum.

(2) Apply one drop of silver nitrate solution (0.5 percent) to a clean surface, A black spot immediately forming on the surface indicates material is magnesium.

k. Tests for Aluminum:

(1) Aluminum is a white metal, light in weight, and ia also nonmagnetic and nonsparking. This metal is two-thirds lighter in weight than steel.

(2) Apply one drop of silver nitrate solution (0.5 percent) to a clean surface. A clear spot remaining on the surface indicates material is aluminum.

(3) Aluminum with a copper content of 0.6 percent or more is known as Duralumin.

1. Tests for Titanium:

(1) Titanium is a white metal, slightly heavier in weight than aluminum and about one-half the weight of steel.

(2) Titanium produces an unforgettable brilliant white stream of sparks when applied to the grinding wheel.

m. Tests for High Temperature Alloys: [4]

(1) All high temperature alloys are white or gray in color.

(2) Except for titanium (a lightweight metal weighing about one-half the weight of steel, and tungsten and molybdenum which are heavy metals), high temperature alloys are of medium weight.

(3) All high temperature alloys except type 446 stainless steel (23-26 percent chromium) are nonmagnetic.

(4) With the exceptions of titanium (which produces brilliant white spark streams), the 300 series and 400 series stainless steels (which produce straw-colored spark streams 14 inches to 18 inches in length), and tungsten (which produces short yellow spark streams), all other high temperature alloys (including type 446 stainless steel) produce short red spark streams in varying lengths between 1 ½ inches to 6 inches when applied to the grinding wheel.

(5) To test for presence of cobalt in high temperature alloys, apply one drop of concentrated nitric acid to a clean surface area. There will be no reaction to the nitric acid. Then, add one drop of concentrated hydrochloric acid to the nitric acid. A blue color developing by itself or within a pea-green color in the solution identifies the presence of cobalt. If the pea-green color develops alone in the solution, cobalt is not present, therefore, test for inconel/hastelloy or type 310 stainless steel. (See procedures in subparagraph (7), below.)

(6) Chemical Spot Testing to Separate High Temperature Alloys Containing Nickel with Cobalt from Alloys Containing Nickel with no Cobalt.

(a) Clean surface of the sample.

(b) Apply nitric acid.

(c) Add hydrochloric acid.

(d) A blue (turquoise) color appearing in the solution indicates cobalt is present in the alloy (if pea-green only, proceed to (e), below). Next add Solution B (which is a test for nickel) to determine the comparative quantity of nickel in an alloy. A deep red color indicates high nickel content and low cobalt content. A pink or faint red color indicates low nickel content and high cobalt content.

(e) A pea-green color indicates that the alloy does not contain cobalt. Next add potassium ferricyanide (which is a test for iron). A brown color indicates an alloy with low iron content and high nickel content (e.g., type 310 or 314 stainless steel, Timken 16-25-6, Incoloy, other alloys which have a higher nickel content than the 300 series stainless steel group).

(7) To distinguish Inconel and/or hastelloy from type 310 stainless steel:

(a) Upon determining from the "test for cobalt" that the stainless steel or high temperature alloy contains no cobalt, add a few drops of potassium ferricyanide solution (10 percent) to the nitric and hydrochloric acid already on the sample and observe.

(b) A brown color developing in solution indicates low iron; therefore, Inconel or hastelloy.

(c) A blue or blue-black color developing in solution indicates high iron; therefore, type 310 stainless steel. The 300 series stainless steels also develop these colors, but they are readily separated from type 310 stainless steel by the spark test. Spark streams from type 310 are approximately 6 inches in length, whereas other 300 series spark streams are 12 to 18 inches in length.

(8) To distinguish high cobalt alloys from low cobalt alloys:

(a) Upon determining from the "test for cobalt" that the alloy contains cobalt, add a few drops of Solution B to the nitric and hydrochloric acid already on the sample and observe.

(b) A faint or pale pink color developing in the solution indicates low nickel and therefore high cobalt.

(c) An extensive red color developing in the solution indicates high nickel and therefore low cobalt.

n. Tests for gold or gold-plated metals.

(1) Gold is a yellow metal and very heavy. It is usually plated on medium weight metals such as steel, nickel or copper-base alloys; but it may also be plated on lightweight metals such as aluminum.

(2) Gold is a nonmagnetic and nonsparking metal.

(3) Nitric acid has no effect on gold or gold-plated metals.

(4) To identify the base metal in a gold-plated sample, file a small niche in it and apply a drop of nitric acid. If the nitric acid attacks the base metal and a green color appears in solution, it indicates a copper-base alloy. In the event that gold has been plated on a high-value metal, such as nickel for example, the total value of the nickel

[4] For further information on high temperature alloys, see chapter V, paragraph C.

might be much greater than that of the gold plating.

(5) To test for the presence of gold, complete the following test:

(a) Clean the surface to be tested of any dirt, grease, or other organic surface coatings. There must be direct contact between the metal and reagents, otherwise reaction will not take place.

(b) Gold is soluable in Aqua Regia (AR) which is 3 parts hydrochloric acid and 1 part nitric acid. Add AR to the surface and wait for a reaction. Before the AR penetrates the gold and starts attacking the base metal, add 3 drops of water. (The solution only has to be slightly acidic but at the same time has to have enough gold to provide an adequate test.)

(c) Pick up some of the solution on a strip of filter paper and on the zone of the contact add 2 drops of Stannous Chloride ($SnCl_2$). If pinkish red color develops then plating is gold. *Caution:* Some red colored anodized aluminum, when acted upon by HCl or AR, may have the red dye dissolve. Don't mistake it for gold.

o. Test for silver or silver-plated metals.

(1) Silver is a white, heavyweight metal. It is unsually plated on medium or lightweight metals.

(2) Silver is a nonmagnetic and nonsparking metal.

(3) Place one drop of nitric acid on the sample, then add one drop of hydrochloric acid. A milky white flash forming immediately in the solution, or a white precipitate (similar to fresh fallen snow) forming on the sample, indicates that the metal is silver or silver-plated.

(4) An alternative method of indentifying silver is as follows:

(a) Add 1 drop of nitric acid to the clean surface and then dilute with 2 drops of water. Add 1 drop of potassium chromate (K_2CrO_4) or potassium bichromate ($K_2Cr_2O_7$) and a red precipitate or blood-like coloration will form indicating silver.

(b) For fine silver adding a drop of silver nitrate ($AgNO_3$) will cause no reaction. If the silver is alloyed with copper, the reagent will leave a dark spot. The more copper in the alloy, the darker the spot.

p. In addition to the above methods in identifying metals and alloys, other methods used for making a preliminary identification, principally by dealers specializing in specific grades or types, include the following

(1) *Naval Bronze.* Using an electric drill, obtain a pigtail turning from its drillings. The inner surface of the turning will reveal a reddish color. The turning breaks apart readily when pulled.

(2) *70/30 Brass.* Using an electric drill, obtain a pigtail turning from its drillings. The inner surface of the turning will reveal a yellowish color. The turning breaks apart readily when pulled.

(3) *Silicon Bronze.* Using an electric drill, obtain a pigtail turning from its drillings. The turning does not break apart readily when pulled but feels springy.

(4) *Muntz Metal Tube.* Fractured (not cut) end reveals a brownish color in its break.

(5) *Admiralty Metal Tube.* Fractured (not cut) end reveals a greenish color in its break.

(6) *Beryllium Copper.* Heat sample to a cherry red pitch just below its melting point, then immerse in cold water. Beryllium copper retains its original surface color after cooling, whereas other copper-base alloys develop a red color on their surface.

(7) *Platinum and Other Precious Metals.* Heat sample until white hot, allow it to cool under normal conditions. Platinum or a high platinum alloy will retain its original surface color after cooling, whereas other white or steel-gray precious metals will become dark or black.

(8) *Aluminum.* Draw a sharp knife along an edge of the sample. Aluminum is a soft metal and will peel into a pigtail turning with the movement of the knife.

(9) *Magnesium.* Draw a sharp knife along an edge of the sample. Magnesium chips and breaks off with the movement of the knife. Also, magnesium filings burn with a hot, white light when ignited.

6. *Test Procedure Charts.* The following charts provide step-by-step guidance for identification of metals and alloys. Figure IV–4 applies to very heavy metals; Figure IV-5 to heavy metals; Figure IV-6 to light metals and alloys; Figure IV-7 to copper and copper alloys; and Figures IV–8 through IV-14 apply to ferrous and nonferrous metals and alloys.

7. *Metal Identification Tables.* Table IV-3 references various identification tests and end use applications of specific ferrous and nonferrous metals. Table IV–4 lists chemical symbols of metals. Table IV–5 explains spark test results on some common metals and Table IV-6 summarizes the basic testing methods (visual, magnetic, spark, and chemical) used in metals identification.

Table W-3. Identification of Metals

The Department of Defense recognizes the complexities involved in the identification and proper segregation of metals and has established a program to help solve the problem. The proper segregation and classification of metals is of prime importance both to the government and the purchaser. Sorting is the segregation of metals into proper groups of classifications, prior to offering for sale. Metals should be properly segregated with various objectives in mind, such as:

(1) Increases customer interest.
(2) Increases the monetary value of scrap metals.
(3) Failure to remove offgrade reduces the monetary value of prime materials.
(4) Decreases cost of quality control in the manufacture of industrial products,
(5) Allows reuse of minerals which might otherwise be lost during smelting.
(6) Saves important natural resources for future generations.

Table IV-3. *Identification of Metals*

[Reference table]

Metal	Color	Magnet test	Nitric acid test	Ammonia test	Normal composition, percent	Typical uses
	Light gray	Nonmagnetic	Soluble	White reaction	Al, 99.9+	Aircraft, kitchenware and machine castings.
Alcoa 2S	do	do	do	do	Al, 99+	Containers, tanks, auto body parts.
Alcoa 3S	do	do	do	do	Al, 98+	Structural work, tank cars, pipes, storage containers.
Alcoa 24S	Dark gray	do	do	do	Mn, 0.8; Si, 0.8; Cu, 4.5; Al, balance.	Aircraft structure, wings, pontoons.
Alcoa 62S	do	do	do	do	Cu, 0.04; Si, 0.08; Mg, 1.2; Al, balance.	Marine applications.
Alcoa 75S	Dark gray	Nonmagnetic	Soluble	White reaction	Cu, 1.6; Cr, 0.3; Mg, 0.2; Al, balance.	Light alloy parts, aircraft.
Alcoa 112	do	do	do	do	Cu, 7; Zn, 1.7; Fe, 1.5; Si, 1; Al, balance.	Crank cases, oil pans, motor housing, vacuum sweeper parts. Pistons, valve guides, cam shaft bearings.
Gilding, 95 percent	Dark Red	do	Green	Dark blue	Cu, 95; Zn, 5	Bullet jackets, firing pin support shells, fuze caps, primers.
Gilding, 90-10	do	do	do	do	Cu, 90; Zn, 10	Screen cloth, weather stripping, kick plates, line clamps, marine hardware, riveta, screws, screw shells, primer caps, ornamental trim and screen wire.
Red brass	Pinkish-white	do	do	do	Cu, 85; Zn, 15	Fire extinguishers, electric sockets, plumbing pipe, pump lines, radiator cores, faucets.
Red casting brass, 85-5-5-5.	do	do	do	do	Cu, 85; Sn, 5; Pb, 5; Zn, 5...	Castings and hardware.
Red brass, 80-10-10	do	do	do	Light blue	Cu, 80; Sn, 10; Pb, 10	Bushings, bearings, high compression.
Red brass, 88-10-2	do	do	do	Dark blue	Cu, 88; Sn, 10; Zn, 20	Pipe lines and fittings. General machinery construction of gears.
18-8 alloy, type 300 stainless.	Bright	do	No reaction	No reaction	Ni, 11.0 max; Cr, 20.0 max; Fe, balance.	All stainlees steel applications, to include food-dairy-oil-chemical industries.
Mu-Metal	Gray	Magnetic	P green	Light blue	Ni, 75; Cu, 6; Cr, 2; Fe, balance.	Audio transformers, sensitive relays.
Nickel steel, 50 percent	Bright	do	No reaction	No reaction	Ni, 50 max; Fe, balance	Floor plates, reflectors, hardware, staplings.

Table IV-3. *Identification of* Metals-Continued

[Reference table]

Metal	Color	Magnet test	Nitric acid test	Ammonia test	Normal composition, percent	Typical uses
Nickel steel, 30 percent	do	do	do	do	Ni, 30; Fe, balance	Floor plates, reflectors, hardware, staplings.
Projectile skew	Dark gray	do	do	do	Cr, 2.4; C, 0.8; Mn, 0.4; Si, 0.2; Fe, balance.	Artillery projectiles.
Aluminum steel	Light gray,	do	do	do	Cr, 1.15; Mn, 0.5; Si, 0.25; C, 0.25; Fe, balance.	Structural parts.
Tungsten	Bright	Nonmagnetic	No reaction	No reaction	W, 99.0 min.,	Welding electrodes and electronic parts.
Gray cast iron	Dull gray	Magnetic	Brown	Red brown	C, 3.5 max; Si, 0.8 rein; Fe, balance.	Plumbing, hardware, fittings, pipes, radiators, boiler jackets, motor blocks.
Cast iron, malleable	do	do	do	do	C, 2.5 max; Mn, 0.35; S, 0.1; Si, 1.2; Fe, balance.	Railway and automotive castings.
Low brass	Yellow to Pink	Nonmagnetic	Green	Dark blue	Cu, 80; Zn, 20	Battery caps, ornamental metal work, bellows, musical instruments, flexible hose, pump line.
Cartridge brass	Light yellow	do	do	do	Cu, 70; Zn, 30,	Radiator cores and tanks, lamp fixtures, socket shells, ammunition components, plumbing brass goods.
Yellow brass	Yellow	do	Light green	do	Cu, 65; Zn, 35	Lamp fixtures, flashlight shells, reflectors, bead chain, kick plates, locks, plumbing accessories, sink strainers.
Muntz metal	do	do	Green	do	Cu, 60; Zn, 40.,	Large nuts & bolts, brazing rod, condenser plates, condensers, evaporator and heat exchanger tubes.
Leaded commercial bronze	Orange-yellow	do	Light green	Light blue	Cu, 89; Pb, 1.75; Zn, 9.25.,	Hardware, fittings, screws, nuts and bolts.
Medium leaded brass	Yellow	do	do	do	Cu, 65; Zn, 34; Pb, 1	Butts, gears, nuts, rivets, screw dials, engravings and instrument plates.
High leaded brass	do	do	do	do	Cu, 66; Pb, 1.6; Zn, 33	Channel plate, clock plates and nuts, clock gears and wheels, telescope secondary items.
Free cutting brass	do	do	do	do	Cu, 61.5; Pb, 3; Zn, 35.5	Gears, pinions, automatic high speed screw machine parts and accessories.
Leaded muntz metal	Light yellow	do	Dark green	Dark blue	Cu, 60; Pb, 0.6; Zn, 39.4	Condenser tube plates.
Admiralty brass	do	do	Green	do	Cu, 70; Sn, 1; Zn, 29	Condenser, evaporator and heat exchange tubes, condenser tube plates, distiller tubee, ferrules.
Naval brass	Dark yellow	Nonmagnetic	Green	Dark blue	Cu, 60; Sn, 0.75; Zn, 39.25	Aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, structural uses, valve stems.
Leaded naval brass	do	do	do	do	Cu, 60; Sn, 0.75; Pb, 1.75; Zn, 37.5.	Marine hardware, screw machine products, valve stems.
Manganese bronze	Bright yellow	Slightly	do	do	Cu, 58.5; Sn, 1; Fe, 1.4; Mn, 0.1; Zn, 39.	Automotive clutch disks, pump rods, shafting, balls, valve stems and bodies.
Aluminum brass	Light-yellow	Nonmagnetic	Dark green	Light blue	Cu, 76; Al, 2; Zn, 22	Bushings, gears and general hardware.

Table IV-3. *Identification of Metals*—Continued

[Reference table]

Metal	Color	Magnet test	Nitric acid test	Ammonia test	Normal composition, percent	Typical uses
Phosphor bronze, 5 percent.	Dark red	do	Blue-green	Dark blue	Cu, 95; Sn, 5	Beater bars, bellows, tubing clutch disks, cotter pins, fuse clips, lock washers, truss wire, wire brushes.
Phosphor bronze, 1.25 percent.	do	do	do	do	Cu, 98.75; Sn, 1.25; P, trace.	Electrical contacts, flexible hose, pole-line hardware.
Phosphor bronze, free-cutting.	Light red	do	do	do	Cu, 88; Pb, 4; Zn, 3.5+	Bearings, bushings, gears, pinions, shafts, thrust washers, valve parts.
High-silicon bronze	Red-yellow	do	Light gray	Light blue	Cu, 96; Si, 3	Propeller shafts, bearing plates, bushings, kettles, piston rings, marine hardware, screen cloth and wire.
Low-silicon bronze	do	do	do	do	Cu, 97.5; Si, 1.5	Anchor screws, bolts, cable clamps, machine screws, marine hardware, U-bolts, electrical conduits, welding rod.,
Cupro-nickel, 70-30	Light gray	do	Blue-green	Blue	Cu, 70; Ni, 30	Condensers, condenser plates, distiller tubes, evaporator and heat exchanger tubes, ferrules, salt water piping.
Cupro-nickel, 80-20	Tan-Pink	do	do	do	Cu, 80; Ni, 20	Condenser tubes, heat exchanger tubes.
Cupro-nickel, 90-10	Tan Pink	Slightly	Blue-green	Blue	Cu, 88.7; Fe, 1.3; Ni, 10.	Condensers, condenser plates, distiller tubes, evaporator and heat exchanger tubes, ferrules, salt water piping.
Nickel-silver, 65-18	Gray to yellow	Slightly to nonmagnetic.	Bluish-green	Dark blue	Cu, 65; Ni, 18; Zn, 17	Rivets, screws, table flatware, truss wire, zippers, camera parts, radio dials.
Copper, electrolytic	Red	Nonmagnetic	Blue-green	do	Cu, 99.9	Electric conductors, pipes, electronic parts.
Copper, oxygen-free, H. C.	do	do	do	do	Cu, 99.99	Wire, conductors, switches, electronic accessories.
Copper, phosphor	do	do	do	do	Cu, 99.9; P, 0.1	Bearings and machine castings.
Copper, tough pitch	do	do	do	do	Cu, 99,9; o, 0.1	Gaskets, radiators, radio and television parts, electric switches, gutters, *roofing*, screening and downspouts.
Nickel	Dark gray	Strongly	Pale green	Blue	Ni, 99	Corrosion resistant and electronic secondary items.
D-Nickel	do	do	do	Light blue	Ni, 94; Mi, 4.5	Spark plug wire and welding rods.
Z-Nickel	Light gray	do	do	Dark blue,	Ni, 94; Al, 4.5	Corrosion-resistant springs.
Monel	Dark gray	Slightly	Greenish-blue	do	Ni, 67; Cu, 30; Fe, 1.4; Mn,	Turbine lades, airplane parts, pump rods, valve stems, valve seats and fittings.
Monel 35	do	do	do	do	Cu, 31.25; Ni, 65.5; Fe, 1	Table tops, kitchen equipment.
K-Monel	Light gray	Nonmagnetic	Green	Blue	Ni, 64; Cu, 30; Fe, 1; Mn, 1; Al, 4.	Springs, nonmagnetic parts, pump rods, check valves, marine parts.
	do	Slightly	do	Light blue	Ni, 63; Cu, 30; Fe, 2; Si, 4...	Machine castings, airplane parts, marine parts.
Inconel	Dark gray	Nonmagnetic	No reaction	No reaction	Ni, 76; Cr, 15.5; C, 0.04; Fe, 7.	Dairy equipment, food handling equipment, airplane exhaust manifolds, cooking equipment.
Inconel X	Light gray	do			Ni, 73; Cr, 15; C, 0.04; Ti, 2.50; Fe, 7; Al, 0.9.	Combustion chambers on jet engines, electronic equipment and springs.

Table IV-3. *Identification of* Metals-Continued

[Reference table]

Met-d	Color	Magnet test	Nitric acid test	Ammonia test	Normal composition, percent	Typical uses
Inconel W	do	do	do	do	Ni, 75; Cr, 15; C, 0.04; Ti, 2.50; 7; Al, 0.6.	High temperature applications, principally used in jet engines.
Nichrome	Bright	Slight/strong	No reaction	No reaction	Ni,60Cr, 15; Fe, balance ...	Heat treating fixtures and resistance wire.
35-15 alloy, type 330 stainless.	do	do	do	do	Ni,35; Cr, 15; Fe, balance.,	Heat treating fixtures, enameling racks,
25-20 alloy, type 310 stainless.	do	Nonmagnetic	do	do	Ni, 20; Cr, 25; Fe, balance..	Heat and corrosion resistant parts.
25-12 alloy, type 309 stainless.	do	do	do	do	Ni, 12; Cr, 25; Fe, balance.,	Heat treating fixtures and jet engine parts. Annealing boxes, furnace conveyors, furnance linings, air preheater,
Nickel cast iron	Bright gray	Magnetic	Light brown	Dark red	Ni, 3; Si, 1.5; Cr. 1; Fe, balance.	Cast gears.
Carbon steel	Dark gray	do	Brown	Red-brown	C, 1.4; Fe, balance	High speed tool cutters, tools, drills, taps.
Chromium steel	Light gray	do	Brown-black	Brown-green	C, 0.15; Mn. 0.5; Si, 0.5; Cr, 6; Mo, 0.65; Fe, balance.	Hot oil piping, high temperature steam pipes.
Manganese steel	Dark gray	Nonmagnetic	Black	Light-dark	Mn, 12; Si, 0.65; C, 1.2	Perforated screens, dipper teeth, journal-box liners, wear plates, screen, rails.
Tungsten carbide	Gray	Slight/strong	No reaction	No reaction	Ni, various; Co, various .	Welding electrodes and electronic parts; projectile cores, cutting tool tips.
Molybdenum	Silver-white	Nonmagnetic	Olive brown	Dark brown	Mo, 99; min	Grids, hooks, and support members in radio and light bulbs, welding electrodes.
18-4-1 tool steel	Light gray	Magnetic	None	None	W, 18; Cr, 4; V, 1; Fe, balance.	Cutting tools.
Molybdenum steel	Dark gray	do	Brown-black	Red-brown	Cr, 1.1; Mo, 0.40; C, 0,30; Mn, 0.7; Fe, balance.	Crankshafts, connecting rods, Stearing knuckles, propeller shafts, front axles, bolts, crank pins and piston rods.
Vanadium steel	do	do	do	do	V, 14.0; C, 1.3; Plus Si, P & S; Fe, balance.	Machinery parts, tools, dies, gears.
Magnesium alloys	Light gray	Nonmagnetic	No reaction	No reaction	Al, 3.5; Zn, 1.5; Mg, balance.	Light alloy parts, airplane wheels, rockets,
Lead. antimonial	White-gray	do	do	do	Sb, up to 25.0; Pb, balance.	Storage battery plates, fuses, bullets, pipes, plumbing accessories.
Lead, No. lard	Gray	Nonmagnetic	No reaction	No reaction	Pb, 99.25; Cd, 0.25; Sb, 0.5..	Valves, cocks, cable sheathing, tank linings.
Zinc	Bluish-white	do	Vigorous reaction-brown smoke.	do	Zn, 99.95	Galvanizing iron and steel, and in electric batteries; also used in sheet or corrugated-sheet form for roofing and siding in building construction.

Table IV-4. **Common Chemical Symbols Used in the Metal Industry**

Name [1]	Symbol	Name	Symbol
Aluminum	Al	Manganese	Mn
Antimony [1]	Sb	Mercury [6]	Hg
Barium	Ba	Molybdenum	Mo
Beryllium	Be	Nickel	Ni
Bismuth	Bi	Osmium	0s
Boron	B	Palladium	Pd
Cadmium	Cd	Platinum	Pt
Calcium	Ca	Radium	Ra
Carbon	c	Rhodium	Rh
Chlorine	c1	Ruthenium	Ru
Chromium	Cr	Selenium	Se
Cobalt	co	Silicon	Si
Columbium [2]	Cb	Silver [7]	Ag
Copper	Cu	Sodium [8]	Na
Gallium	*Ga*	*Sulphur*	**s**
Germanium	*Ge*	Tantalum	*Ta*
Gold [3]	Au	Tin [9]	Sn
Iridium	Ii-	Titanium	Ti
Iron [4]	Fe	Tungsten [10]	w
Lead [5]	Pb	Uranium	u
Lithium	Li	Zinc	Zn
Magnesium	Mg	Zirconium	Zr

[1] Antimony —Stibium. [2] Columbium—Also known as Niobium. [3] Gold—Aurum. [4] iron—Ferrum. [5] Lead—Plumbum [6] Mercury—Hydrargy rum. [7] Silver—Argentum. [8] Sodium—Natrium. [9] Tin —Stannum. [10] Tungsten— Wolfram

Table IV-5. Spark Testing of **Some Common Metals**

Name	Spark test	Name	Spark test
Nickel	*Coarse* red	Chrome Steel or 400 Series Stainless Steel.	Very light and diffused.
D-nickel	Do.		
Z-nickel	Do.	Mu-Metal	Coarse red.
Monel	Do.	Nickel Steel 5—50%	Orange-red white ends.
K-Monel	Do.	Nickel Steel—30%	Yellow white ends.
S-Monel	Do.	Pure Cobalt	Coarse red.
Cupro-nickel	Do.	Cast alloy tool steel (stellite, etc.).	Fine dark red.
Nickel silver	None		
Inconel, inconel X and inconel W, nimonic 75 and 80	Very dark red.	Tungsten	Short yellow-white
		Tungsten carbide	Do.
Nichrome	Fine orange-red.	Molybdenum	Short yellow-orange.
35-15 alloy or type 330 stainless steel.	Coarse *orange-red*	18-4-1 or T-1 tool steel	Dark red fire balls.
		$-6-2 or M-2 tool steel	Orange burst, white ends.
25-20 alloy or type 310 stainless steel	Fine orange-red turning white.	M-1 tool steel	Yellow *burst, white* ends.
		Titanium	Brilliant White.
25-12 alloy *or type* 309., stainless steel	Coarse light orange turning white.		
18-8 or type 300 series stainless steel.	Light and diffused.		

Table IV-6. Summary of Testing Procedures

Material	Color	Principal Elements	Magnetic	Spark Tsst	Chemical Spot Test
No. 1 Heavy Copper. Clean, min. 1/16" thick	Red	99.9 Cu	No	None	None—color alone is identification method.
Mixed Heavy Copper. Coated or soldered	Red	99.9 Cu	No	None	Do.
No. 1 Copper Wire Clean. uncoated, min. 16 ga. thick	Red	99.9 Cu	No	None	Do.
No. 2 Copper Wire. Coated or soldered	Red	99.9 Cu	No	None	Do.
Light Copper. Less than 1/16" thick	Red	99.9 Cu	No	None	Do.
Insulated Copper Wire. Rubber, fabric, plastic covered	Red	99.9 Cu	No	None	Do.
Composition or Red Brace Solids	Pink-White, Smokey, Hazy	85 Cu, 5 Sn, 5 Pb, 5 Zn, (Nominal)	No	None	To be used only to separate from high grade bronze: Silver nitrate will produce a black color in solution.
Yellow Brass Solids	Golden-Yellow	65 Cu, 35 Za, (Nominal)	No	None	None, color alone is identification method, soft as compared to manganese bronze.
Red Brass Pipe	Pink-White, Smokey, Hazy	85 Cu, 15 Zn, (Nominal)	No	None	None, color alone, when compared with yellow brass pipe, is identification method.
Yellow Brass Pipe	Golden-Yellow	70 Cu, 30 Zn, (Nominal)	No	None	None, color alone, when compared with red brass pipe, is identification method.
High Grade Bronze, (M Metal)	Pink-White, Smokey, Hazy	88 Cu, 10 Sn, 2 Zn, (Nominal)	No	None	To be used only to separate from composition or red brass: Silver nitrate will produce clear or gray color in solution.
Manganese Bronze	Golden-Yellow	58 Cu, 39 Zn, 3 Fe, (Nominal)	Slightly, filings on paper more evident	None	None, hard, brittle and coarse when compared to yellow brass.
Cupro-nickel 70/30	Light Gray	70 Cu, 30 Ni	No	Short red if hard pressure applied to grinding wheel.	Nitric acid will produce a spontaneous green color of copper. Add hydrochloride acid and solution "B" which will produce the red color indicating nickel. Avoid heating specimen.
Cupro-nickel 90/10	Light-Brown	90 Cu, 10 Ni	Non-magnetic to slightly magnetic	*None*	Same as above.
Nickel Silver	Gray to slightly Yellow	60 Cu, 20 Zn, 20 Ni, (No fixed composition)	No to slightly	None	Nitric acid will produce a spontaneous green color and vigorous reaction and an *immediate* puff of brown smoke Specimen will develop a pink color after acid is washed off with water.
Silver Plated	Light-Gray	99.9 Ag in Plating Only	No, unless base metal is steel or pure nickel	None	Nitric acid and hydrochloric acid will produce a milky-white precipitate in the solution on the plated surface. After removing plating, if base metal is a copper base alloy, nitric acid will turn green. If base metal is aluminum, -the specimen will be light in weight. If base metal ia steel, the specimen will be *magnetic.*

Table IV-6. Summary of Testing Procedures—Continued

Material	Color	Principal Elements	Magnetic	Spark Test	Chemical Spot Test
Silver	Light-Gray	99.9 Ag	No	None	Place small portion of specimen in glass beaker containing nitric acid, permit some of the specimen to dissolve. Remove specimen and add hydrochloric acid. A white precipitate or snowy white color forming immediately in the solution indicates silver. First ascertain that material is uniform throughout. For silver plate on different base metal see procedures outlined above.
Gold plated	Yellow	99.9 Au in plating only	No, unless base metal is steel or pure nickel	None	Nitric acid will have no effect on gold plated surface. After removing plating, if base metal is a copper base alloy, nitric acid will turn green. If base metal is aluminum the specimen will be light in weight. If base metal is steel the specimen will be magnetic. If specimen is very heavy, suspect heavy gold plating or solid gold.
Gold	Yellow	99.9 Au	No	?/one	Nitric acid will have no effect on gold. First ascertain that material is uniform throughout. For gold plate on different base metal, see procedure outlined above.
Aluminum	Light-Gray	99.9 Au and variations	No	None	Silver nitrate will remain clear in solution.
Magnesium	Light-Gray	90 Mg, 3/6 Al, 1/2 Zn (Nominal)	No	None	Silver nitrate will produce a dark gray to black color in solution. Filings will burn like a flare.
Lead	Dark-Gray	99.9 Pb and variations.	No	None	None.
Zinc	Bluish-Gray	99.9 Zn and variations	No	None	Nitric acid applied to filings will produce effervescent and spontaneous brown smoke. Solution will remain clear with no precipitation.
Tin	White	99.9 Sn	No	None	Nitric acid applied to filings will produce yellow smoke and yellow color on surface of solution, good amount of white precipitation will remain in solution.
Kirksite and Zinc Die Cas	Bluish-White	93 Zn, 2/4 Cu, 4/5 Al and variations	No	None	Nitric acid applied to filings will produce a spontaneous light brown smoke similar to but lighter than zinc. Solution will appear greenish with no precipitation.
Monel (Except Monel "K")	Light-Gray	70 Ni, 30 Cu, (Nominal)	Slightly	Very short dark red.	Nitric acid will produce a delayed milky green color. Avoid heating specimen.
Titanium	Light-Gray	80 Ti, min., (Nominal)	No	Brilliant white spark 12' to 18" long with star and shell bursts.	None.
Monel "K"	Light-Gray	64 Ni, 30 Cu, 4 Al, (Nominal)	No	Very short dark red.	Same as Monel.

Table IV-6. Summary of Testing Procedures—Continued

Material	Color	Principal Elements	Magnetic	Spark Test	Chemical Spot Test
Nickel	Light-Gray	99.9 Ni	Strongly	Very short dark red.	Nitric acid will slowly develop a clear pale green color in the solution, Add hydrochloric acid and Solution "B" to develop the red color indicating nickel.
300 Series Stainless Steel, AF Group No. 1	Light-Gray	17/19 Cr, 7/9 Ni, bal. Fe (Nominal)	No, except stamping, forming, bending and cold working create slight magnetic properties	Not as dense or profuse as carbon steel. Orange to straw colored sparks which travel completely around the grinding wheel ending in a straight line 12" to 18" long without starbursts.	Nitric acid will produce *no* reaction. Add hydrochloric acid which will produce a pea green color. Add Solution "B" to develop the red color indicating nickel, Add potassium ferric yanide which will produce a blue-black color indicating high iron content. Note: Types 310, 314 and 330 stainless steel will react exactly the same. However, the spark characteristics are different.
310 Series Stainless Steel, AF Group No. 14	Light-Gray	25 Cr, 20 Ni, bal. Fe	No	Short red turning orange. Sparks are approx. 6" long and do not travel around the grinding wheel. No starbursts in carrier lines.	Same test as above for 300 series Stainless Steel will produce the same results. However, the spark test will separate one from the other.
400 Series Stainless Steel, AF Group No. 2	Light-Gray	11/18 Cr, bal. Fe	Strongly	Not as dense or profuse as carbon steel. Orange to straw colored and travel completely around the grinding wheel. Sparks are 14" to 18" long and end with the appearance of a split tongue burst.	None.
Inconel, Inconel X, Inconel W, Nimonic 75 and 80, AF Groups No. 8 and No. 16	Light-Gray	14/20 Cr, 73/77 Ni, bal. Fe	No	Very short red 1%" to 2" long and do not travel around the grinding wheel.	Nitric acid will produce no reaction, Add hydrochloric acid which will then produce a pea green color. Add Solution "'B' to develop the red color indicating nickel. Add potassium ferricyanide which will then produce a brown color indicating low iron content.

Table IV-6. Summary of Testing Procedures—Continued

Material	Color	Principal Elements	Magnetic	Spark Test	Chemical Spot Test
Hastalloy—"C" A F Group No. 4	Light-Gray	16 CR, 57 Ni, 17 Mo, 4 W, bal. Fe	No	Very short red 1 %" to 2" long and do not travel around the grinding wheel.	Same as Inconel and Nimonic AF Groups No. 8 and No. 16. Reaction will be exactly the same. Note Hastalloy "C", Inconel and Nimonic 75 *and 80 cannot be* positively identified one from the other by spot testing. Lacking further identification by chemical or spectrographic analysis description should be as follows: "Inconel, Nimonic 75 and 80, and/or hastalloy".
Low Cobalt-High Nickel, AF Groups No. 18 and No. 28 Waspalloy and Thetaloy (Nickel Base-Cobalt Bearing)	Light-Gray	19/25 Cr, 55/60 Ni, 12/13 Co.	No	Very short red 1 ½" to 2" long and do not travel around the grinding wheel.	Nitric acid and hydrochloric acid will develop a blue (turquoise) color indicating cobalt. Add Solution "B' to develop deep red color indicating nickle. An intense deep red color indicates a high nickel content which in turn means a lower cobalt content. A pale pink color indicates a low nickel content which in turn means a higher cobalt content.
High Cobalt—Low Nickel, AF Groups No. 3, No. 9 and No. 15 (Cobalt Base—Nickel bearing)	Light-Gray	12/27 Cr. 1/20 Ni, 40/67 Co.	No	Very short red 1 ½" to 2" long and do not travel around the grinding wheel.	Same as Low Cobalt—High Nickel, AF Groups No. 18 and No. 28.
Armor Plate and Low Alloy Steel containing Nickel	Gray	1% to 5% Ni, bal. Fe		Same as normal carbon steel. Sparks are dense and long, travel completely around the grinding wheel, generally white to straw colored with bursts throughout the carrier lines.	Apply Solution "A" and let it react for 30 seconds. Blot with white blotting paper, add Solution "B" on blotter. A very deep red color indicates a nickel content of 3% to 5%. A pink color indicates a nickel content of 1% to 270.